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PROCEEDINGS

OF THE

TWENTY-FIFTH ANNUAL

CONVENTION

OF THE

American Water Works Association

HELD AT

WEST BADEN, IND.

MAY, 1905.

PUBLISHED BY THE SECRETARY

The Association is not responsible, as a body, for the facts and opinions advanced in any of the papers or discussions published in its proceedings.

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BENJAMIN C. ADKINS, President.

PROCEEDINGS

OF THE

TWENTY-FIFTH ANNUAL CONVENTION

OF THE

AMERICAN WATER WORKS ASSOCIATION

HELD AT

WEST BADEN, IND.

MAY 9, 10, 11, 12, 1905.

The Twenty-fifth Annual Convention of the American Water Works Association was held at West Baden Springs, Ind., on May 9, 10, 11 and 12, 1905.

All of the business sessions and social functions were under the same roof.

The ball-room was utilized as a convention hall, for which it was admirably suited, being well lighted, free from external noises or disturbances, and possessing excellent acoustic properties. It was handsomely draped for the occasion with the national colors.

The following is a full report of the proceedings of the convention.

FIRST—MORNING SESSION.

The opening session was called to order at 10 :30 A. M., by President Sherrerd. There was a good attendance, something over one hundred active members being present, besides their ladies and guests.

In opening the convention President Sherrerd said: Ladies and Gentlemen: The Twenty-fifth Annual Convention of the American Water Works Association is now open. The first matter on the program is the roll call, which is usually dispensed with until later in the convention, as the Secretary will have the list of all members in attendance printed and distributed. The minutes of the last convention have been printed in full and members and others supplied with copies. If there are no corrections or suggested changes in those minutes, they will stand approved as published.

The next on the order of the program is election of new members. The Secretary will submit applications.

Secretary Diven read the following applications for active and associate membership:

ACTIVE

T. C. Phillips, Water Works Engineer, 220 Broadway, N. Y.

Will J. Sando, Water Works Commercial Consulting Mechanical Engineer, 26 Gramercy Park, N. Y. City.
(Now with Allis-Chalmers Co.)

Fred B. Roblin, Manager Water & Electric Co., Kalispell, Montana.

Andrew S. Corr, Inspector Cast Iron Pipe, 146 Washington Street, Phillipsburg, N. J.

Ulrich E. Taubenheim, Manager Water Works, Archangel, Russia.

Nisbet Wingfield, Consulting Engineer, Augusta, Ga.

James Rittenhouse Evans, Chemist, 19 High Street, Pottstown, Pa.

A. N. Meyers Water Registrar, Milwaukee, Wis.

Marshall R. Pugh, Civil Engineer, 1334 Real Estate Trust Building, Philadelphia, Pa.

William Blanchard Gerrish, Superintendent Water Works, Oberlin, Ohio.

F. H. Pitcher, General Manager & Chief Engineer, Montreal Water & Power Co., 62 Alliance Building, Montreal, Canada.

John F. J. Mulhall, Secretary Knoxville, Tenn., Water Co., 62 Astoria Street, Boston, Mass.

H. H. Shaw, Manager Municipal Water Works Co., Portland, Me.

Chas. W. Fenn, C. E. & Manager Water Works, Portland, Me.

Edgar R. Payson, Treasurer & Superintendent Water Works, Portland, Me.

C. Arthur Brown, Sanitary Engineer, Lorain, O.

Daniel B. McCarthy, Superintendent Water Works, Waterford, N. Y.

H. Dallas McCabe, Superintendent Water Co., Monessen, Pa.

Walter D. Pease, City Engineer & Water Commissioner, P. O. Box 218, Cheyenne, Wyo.

J. Ralph Van Duyne, Assistant Engineer Department of Water, Newark, N. J.

Geo. Sanzenbacher, Assistant Engineer & Superintendent, Department of Water, Newark, N. J.

J. F. Witmer, Hydraulic & Sanitary Engineer, Chapin Block, Buffalo. N. Y.

Eli Giclas, Superintendent Water Works, Flagstaff, Arizona.

Ira Gould Hoagland, Mechanical Engineer, 19 Liberty Street, New York, N. Y.

Richard Clark, Superintendent Water Works, Merritton, Ont.

Robert Hollingsworth, Chief Engineer Water Works, Camden, N. J.

Lee Harvey, Superintendent Water Co., Conneaut, O.

W. H. Ferguson, Superintendent Water Works, Springfield, O.

Wm. M. Marple, Chief Engineer Gas & Water Co., Scranton, Pa.

T. W. Burns, City Engineer & Superintendent Water Works, Fairburry, Ills.

Ernest C. Levy, M. D., Sanitary Engineer & Bacteriologist, Richmond, Va.

James A. Omberg, City Engineer, Memphis, Tenn.

Robert Welling, Superintendent Water Works, Covington, Ky.

James De Young, Superintendent Public Works, Holland, Mich.

Walter Wood, Treasurer Millville (N. J.) Water Co., 400 Chestnut Street, Philadelphia, Pa.

James R. Fitzpatrick, Instructor of Mathematics and Surveying, Rensselaer Polytechnic Inst., Troy, N. Y.

ASSOCIATE

General Fire Extinguisher Co., Union Trust Building, Providence, R. I.

The Fairbank Company, Broome and Elm Streets, New York, N. Y.; John F. O'Brien, Representative.

Pittsburg Filter Manufacturing Co., Farmers' Bank Building, Pittsburg, Pa.

Safety Meter Lock Co., Columbus, O.; M. A. Corbet, Mgr.

Ellis-Ford Pipe Cutter Co., Detroit, Mich.

Allis-Chalmers Co., Milwaukee, Wis.

Modern Iron Works, Quincy, Ill.; Geo. F. Fisher, Representative.

President Sherrerd: Gentlemen, you have heard the applications for membership read by the Secretary. Are there any other applications to be submitted? I would state that in compliance with the constitution these applications have been approved by the Executive Committee, and it is in order that they now be voted upon by the Association. The requirement is that this be done by ballot.

On motion, the Secretary was authorized to cast the ballot of the convention in favor of the applicants named in above list. This having been done, the Chair declared the applicants above named duly elected to membership.

President Sherrerd delivered his address, as follows:

PRESIDENT'S ADDRESS.

M. R. Sherrerd, President,

Engr. & Supt. Dept. Water, Newark, N. J.

Gentlemen:

Your President, in reviewing the past year of our Association, is glad to be able to say that it has been one of continued growth and progress. This convention marks the Twenty-fifth year of the life of the Association. From a small beginning with a membership of 20 at the first meeting in St. Louis in 1881, we now enroll 383 active, 71 associate and 7 honorary members for 1904, and the Secretary informs me that he has 48 applications for membership to present for your consideration at this Convention.

During this quarter century of our existence as an association many improvements in the construction and management of water works have been inaugurated. We can fairly credit to our organization, directly and indirectly, a large share of this advancement. In the waterworks field, as in many other branches, the mechanical and physical development of our glorious country has been very much more marked in the last few years than in any previous period of our history.

Now, while this is true in the abstract as regards waterworks, we must admit that comparatively the advance has been slow. Take for instance, electrical development, and compare the rapid strides made in that field with the tendency of the waterworks man to let well enough alone. This is hardly a fair comparison, you say, because the harnessing of electricity is a new art, while the distribution of water dates back to the old Roman. However, this is only an additional reason why improvements should have been more marked and earlier in their inception. Perhaps our best excuse for slow progress is the fact that so much of our work is underground and requires years of experience to determine results. Nevertheless, marked advancement has been made in water matters, and it is only justice to our associate membership to state that this progress is quite as much due to their labors as to the initiative of our active members.

Your President regrets that his recent absence on a rather extended trip has prevented his giving as close attention to the affairs of the association as he fully expected to do when you honored him by selection as your presiding officer. He, however, knew that its interests were left in good hands and the faithful work of the secretary and the several committees has only confirmed his implicit confidence in their loyalty to the association.

Do you appreciate what it means for your secretary, who has recently accepted a new position, to so successfully arrange for a convention, keep up the correspondence, look after the finances, and accomplish the thousand and one things that must necessarily be done for this Association while at the same time taking up the duties and becoming familiar with the ramifications and details incident to assuming charge of a larger and more intricate water plant? He was actually so pressed for time that upon a recent visit of your President to Charleston the secretary in attempting to get from the wharf into a boat was in such a hurry that he dropped his watch in ten or twelve feet of water. Having finally recovered the watch, his present slogan is, watch the watered works! If not spring water, why then something else perhaps "A little oil," but not both.

Having found that the position of President, as has been said by some of your presiding officers, is principally an honorable one; and feeling that I am about to become a Past President, I want to express the wish that I may be able in some degree to advance the interests of the Association, though I cannot expect in any wise to equal the services of our past President, Chairman of the Insurance Committee.

Gentlemen, you will find as this Convention proceeds that you will appreciate the painstaking work of the Chairman of the Insurance Committee, and the ready response of its members (located in five States, from Massachusetts to North Carolina) to meet in New York. Representing their labors in behalf of our Association, reports will be submitted, showing results in matters which have been hanging in the air for years.

We have met the Insurance Representatives half way, and from the joint work of their committee and ours, but more especially due to the support and ingenuity of some of our asso-

ciates, something definite in this line has been accomplished which will be presented at this convention for your consideration.

There is one branch of the waterworks field which is deserving of special and immediate attention. It is within the scope of this Association to seriously review the situation with regard to fire protection engineering. This means more than a new name for an old subject. It means almost radical departure in some phases of waterworks construction. This statement is made after careful consideration. Not many years ago,—perhaps ten,—representatives of the Insurance Companies requested that no street mains less than 6 inches in size be laid. Now, the recommendation is "In general, mains supplying hydrants in important mercantile and manufacturing sections shall be of not less diameter than 12 inches; that all future installations of mains for the supply of hydrants in residential districts be of not less diameter than 8 inches."

In making the above reference it is not the purpose to discuss this and many similar radical suggestions, which, I know, are the result of careful investigations. The best is none too good; and the position of the insurance men will assist each of us in having our recommendation for improvements sustained. From their point of view, however, they would be inclined to take an extreme position. To at once, or within several years, reach such a high standard of perfection will require very large expenditures. Our individual duty should be to see that every expenditure for improvement of water systems for fire protection is made that is possible, and that all expenditures are applied along some systematic plan to obtain the best results.

When, as has been the case in our largest cities, the appropriations of millions of dollars for high pressure systems have been criticised by chiefs of fire departments, while approved by our Insurance friends, they must realize that the Waterworks Superintendent has his own troubles in obtaining appropriations.

How far our Association should go in referring this matter to the present Insurance Committee or to a new committee, would be a proper subject for recommendation from the Executive Committee.

A continuation of the committee work to obtain Standard

specifications is a very important field. Either the scope of the present committee on "Standard Specifications for Cast Iron Pipe" might properly be enlarged to include other waterworks appliances, or a new committee be created as may be suggested by the executive committee.

Your President feels that it is a proper function of this Association to encourage the use of only the best grade of goods in all waterworks supplies. Uniform specifications will assist in obtaining this result, but each member can do more by refusing to accept inferior grades simply because they are cheaper, usually they are not, because of the increased cost of maintenance.

In testing material under water pressure, more than the bare fact that the valve or other appliance was tight and stood so many pounds pressure is necessary in comparing the relative merits. Two large valves of exactly similar design, for instance, may each apparently successfully stand 300 pounds pressure, yet the metal in one, because of inferior quality or slightly less thickness in some part, may become strained beyond its elastic limit and never make as good a valve thereafter, while the other recovers from the strain. In competitive public lettings the tendency must always be to reduce the thickness of the material used to the minimum section which will stand the test. A valve closely designed to work under 100 pounds will be a better valve if only tested to 200 instead of 300 pounds, but if the specifications call for 300 pounds and the test is only carried to 200 pounds, the second set of valves may be made somewhat lighter. This rather intricate statement is given to show the advantage of standard sections and designs, which, if required together with a test of the metal, rather than an extreme hydrostatic test of the finished article, would give something better for general use, and result in bids on more equal conditions.

It has sometimes been asked by members of city councils and others, whether it pays to send delegates to conventions such as this. Unquestionably it does, and one special advantage of having the members of our boards attend, will result in their finding that, as a rule, the things their own superintendent has been urging, are being advocated by a majority of our mem-

bers. After attending one Convention they will not think their superintendent quite as much of a crank as he may have seemed before.

Our associate members also share in personal benefit with the active membership; one phase of the advantage of our intercourse was very nicely expressed at a recent gathering of a small number of our membership, to the effect that an associate enjoyed an opportunity not so well obtained in any other way, to become intimately acquainted with his competitor, know his good qualities and learn that each was only striving for the best interests of the people he represented.

In preparing this address it hardly seemed the proper place to go into details of waterworks matters; some phases of which will be presented to you in the papers to be read and many others will no doubt be brought out in the discussions.

The thanks of the waterworks fraternity is due to those who have labored in the development of the remedy for growths of Algea and especially to Dr. Geo. T. Moore and Karl C. Kellerman of the Department of Agriculture, who first discovered the application of sulphate of copper for this purpose.

Our thanks are also due to those who are encouraging and advancing the study of filtration and its successful application to the purification of water supplies.

Your president desires to take this opportunity to thank the officers of the Association and the Chairmen and members of the several committees for the help and assistance rendered, and for their labors in behalf of the Association and especially in perfecting arrangements for this Convention.

President Sherrerd: It has come to my attention since writing the foregoing that in one city in particular a question has been raised as to the right of city officers to use the city money to pay expenses of delegates to conventions. This is a serious matter, and I think ought to be presented in its best light to the state officers, who I believe in this case are to pass on the question.

Your President has been authorized by the Executive Committee to confer with the Attorney General of the state

in question, with a view to a possible adjustment of this question. I understand that if some specific subject is to be brought before a convention for consideration, that an appropriation can be made to cover the attendance of officials for that specific purpose. I know that in several other organizations of a similar character to the American Water Works Association matters have been brought to the attention of City Boards which were represented at conventions which proved to be of great benefit to the city. In this way, by the expenditure of a few hundred dollars civic boards are enabled to secure benefits that would require the expenditure of thousands of dollars to obtain through actual experience. Cities which send representatives to the conventions of this Association get through them the result of the experience of other cities that have been derived from costly experiments. Membership in this body and attendance at these meetings enables city boards or councils to obtain most valuable data and experience.

In view of all of this I believe that the duty rests upon us to urge the attendance of members of civic boards and of city councils, or some representatives of the legislative departments of city governments, because in this way we can insure to the representative cities beneficial results that they could not otherwise obtain. Engineers themselves can also keep informed as to the progress of scientific discovery and invention and experimental results which will prove most valuable to them in daily waterworks practice.

Mr. C. H. Campbell: The able address just delivered by you has served to impress upon the members of this Association the fact that while Mr. Diven's slogan is "Watch the Water Works," the watch that went over board possibly was too full of water and stopped. Now the difference between that watch and Jack is this, that while that watch stopped, there is no stop to Jack. He keeps going all the time! (Applause.) There is another watch which you did not refer to, however, and that is his combination of strong and vigorous effort and direction to make this Association go forward. A few of us here have got caught in the gear of that powerful engine of intellect which our President

possesses, and the force was so irresistible and so carried us away that it was a matter of impossibility for our committee to be in any wise lax or derelict in their work. But it is perfectly evident while our President very pleasantly compliments those who have co-operated, and shows his appreciation of those who have tried to help him, yet the fact that he is the President, I want to say to you, is the cause and the impetus of the movement and of the good work that has gone forward during the present year. (Applause.)

President Sherrerd: I thank you, Mr. Campbell, and the Secretary.

Secretary Diven: The President's address contains some recommendations which should be acted on. I, therefore, move that it be referred to the Executive Committee to take action on the recommendations, and report at some future session of the convention.

The motion was seconded by Mr. Campbell and carried.

President Sherrerd: You will find a place on the program assigned to reports of the several committees. I understand that some of these are not quite formulated, but that of the Committee on Insurance is ready, I believe. They are on the program for a later time, but since the representatives of the National Fire Protection Association, who are in attendance to-day, have other engagements later in the week, they have requested that we now hear the report of the Committee on Insurance, Mr. C. H. Campbell, Chairman.

Mr. Campbell: Mr. President and members of the American Water Works Association: Two years ago, at the Detroit Convention, a standing Committee was appointed, entitled "Committee on Fire Insurance." At the St. Louis Convention this Committee was continued, as a whole. We have not been moving rapidly, but we have tried to carry our work forward by steady intelligent thought on the subject before us. There is so much for this Committee to do that it will go on from time to time and its work will never be done.

The committee has so far taken up different subjects as they arose and has endeavored to handle them in a way to benefit the Association. This work can continue in the future, as this is a standing committee, although its membership, of course, will change from time to time according to the work in hand and the disposition on the part of its several members to carry it forward.

Before reading the report proper of the committee, I would like to read a letter from Mr. E. V. French, who is Chairman of the National Fire Protective Association, entitled "Private Fire Service Committee." I am very sorry that Mr. French is not here in person, but Mr. Robinson and Mr. Blauvelt are acting in his stead.

The letter is self-explanatory, and is as follows:

Inspection Department
Associated Factory Mutual Fire Insurance Companies.
Boston, Mass., May 6, 1905.

C. H. Campbell, Esq.,
American Water Works Association, West Baden Springs Hotel, West Baden, Ind.

Dear Sir:—I am not sure yet whether Mr. Robinson will be able to be at West Baden; I am therefore enclosing herewith a brief description of our fire service meter, with the blue print showing the form in which we expect to build it. If Mr. Robinson succeeds in getting there, will you kindly hand him the enclosed letter, which will give him some information on our meter in addition to that which he obtained when here, and if Mr. Robinson is present he will present the matter to the convention, if you so desire. If Mr. Robinson does not succeed in getting there, I would be glad if you would use the description and print as you think best, reading it to the Convention or simply using it in your Committee as your judgment dictates.

Your committee of course understands that we have been working on this problem a good while and this is the outcome. We believe this device will do the work, and we propose at the earliest possible moment to have a number of these meters manufactured so that they can be used where

desired. We expect that other meters will be developed, very likely better than this one, and we hope this will be the result as our only aim is to have on the market a thoroughly reliable fire service meter, satisfactory to the Water Departments, and of such design that it does not endanger the fire service.

I showed the actual meter with which we have been experimenting very fully to Mr. Thomas a few days ago, and while I had expected that he would be at the Convention, find now that he is not going, but that he will write you as to what he has seen, thus giving you from one of your own Committee members, an actual report of the device as it stands to-day.

Again wishing you a most successful convention, and regretting that I can not be there, I remain,

Yours very truly,

E. V. FRENCH,

Chairman Committee N. F. P. A.

P. S.—Have just received telegram from Mr. Robinson that he would be at West Baden Tuesday, and am therefore sending letter and enclosures directly to him at Colonial Hotel.

And I, also, have the following letter from Mr. Thomas:

Lowell, Mass., May 5, 1905.

Mr. C. H. Campbell, Chairman Committee on Fire Insurance, West Baden, Ind.

Dear Sir:—Your letter calling meeting of the Insurance Committee at West Baden was duly received. I regret very much that matters in connection with the water department prevent my attendance.

I want to report, however, that representing the Committee on Fire Insurance I witnessed a test of the meter which Mr. E. V. French of the Factory Mutuals Insurance Company described at our meeting in New York on April 25th. This meter, as Mr. French told us, is similar to the Hersey Detector Meter. That is to say, it consists of a swing check on a 6-inch main pipe, with a 3-inch meter on a by-pass; in this case, however, the by-pass is over the check

instead of on the side. Another difference is, that the flow is registered proportionately when the check is open. Under the direction of Mr. French the meter was run on flows from 70 gallons per minute up to 1,700 gallons per minute, working satisfactory in every respect. Whether it would do as well in ordinary every day use can of course only be determined by such service. This much is apparent, that the Factory Mutuals have gone to considerable expense and are very much in earnest in their endeavor to design or devise a meter for fire service, thereby showing that they recognize the need and the advisability of placing meters on such pipes. I feel very greatly encouraged from the result of Mr. Tilden's work as well as Mr. French's, and feel that the problem of metering fire service pipes will soon be solved and settled so that losses to water departments and water companies from this source will be eliminated.

Wishing you a very successful convention,

Very truly yours,

R. J. THOMAS.

I wish to say in connection with what Mr. Thomas states, that our Committee in all its Conference work and in all its correspondence with the Private Fire Service Committee of the National Fire Protection Association have found that those gentlemen are endeavoring to work with us in harmony. What they are doing is in good faith. They are trying to meet our requirements as far as possible where it does not interfere with the flow of water in the sprinkler system when the same is required for fire service.

The gentlemen of the National Board of Fire Underwriters, with headquarters in New York City, gave us very courteous attention when our committee met there, and the local officers and others who had charge of the offices there did everything that they could to facilitate our work, furnishing us stenographers, typewriters etc.; and we found that the reports furnished of our proceedings were correct.

I will now read the report of the Committee:

REPORT OF COMMITTEE ON FIRE INSURANCE.

To the American Water Works Association:

Gentlemen:—This Committee has the honor to report that it has endeavored to faithfully perform the duties assigned to it, which were continued at the St. Louis Convention; and we herewith present our findings, which are as follows:

First. We desire to reiterate our conviction that inasmuch as the private fire protection which is furnished by the water departments of the country is a valuable consideration and very materially affects the efficiency of the fire protection service generally, that this private fire service should be paid for by the owners of the property so safeguarded and protected; and that the appliances for introducing and measuring the water so used should be paid for by said owners just as much as the piping, hydrants and sprinkler-heads inside of the buildings or on the premises.

Second. This Committee has used all the resources at its command to secure information and to make a thorough investigation into the subject of the practical use of meters on private fire service lines, and to eliminate as far as possible the objection of the fire insurance underwriters to the use of such appliances on account of their claimed retardation of the flow of water at a time when the greatest pressure is required for the sprinkler system service.

We have been very much encouraged in our work by the great interest shown by some of our associate members, and also through the co-operation of the private fire service committee of the National Fire Protection Association, who have displayed a sincere desire to assist our Committee in reaching a satisfactory and final solution of this problem.

The result of tangible work so far in this direction is fully set out in the exhibits made by Mr. J. A. Tilden, the General Manager of the Hersey Manufacturing Co., and also by Mr. E. V. French, Chairman of the Private Fire Service Committee of the National Fire Protection Association, which are hereto attached.

The Chairman of your Committee on Fire Insurance, feeling that it would be practically impossible to reach an

intelligent determination of what would be the best manner in which to formulate the views and ideas of the Committee by correspondence, called a conference meeting at the rooms of the National Board of Fire Underwriters in the City of New York on April 25, 1905, to jointly consider with the Fire Service Committee of the National Fire Protection Association the subject above referred to. This call was very heartily responded to by the members of the Committee, and the following associate members, to wit:—

W. G. Zick, Neptune Meter Co.; Fred S. King National Meter Co.; H. F. Peake, Worthington Meter Co.; L. H. Nash, National Meter Co.; E. F. Walker, Worthington Meter Co.; J. A. Tilden, Hersey Manufacturing Co.; Fred A. Smith, Hersey Manufacturing Co.; also, E. V. French Chairman National Fire Protection Committee; H. A. Fiske, of same Committee.

After thorough discussion and careful deliberation, the sense of the Conference Committee was embodied in a resolution which your present Committee endorse and have embodied in the following recommendation which we respectfully recommend to this Association for approval, to wit:

Whereas: This Committee after several years' work on the problem of obtaining some means of measuring the supply of water furnished through private fire lines which would meet the requirements both of water departments and insurance representatives, and,

Whereas: From the joint efforts of this committee and a corresponding committee from the National Fire Protection Association there has been presented to a conference committee of the two organizations two devices which give promise of meeting the above requirements; and,

Whereas: At a conference meeting of the committees representing the two organizations the following motion was adopted, viz:

"That it is the sense of this conference that an apparatus embodying an indicating check valve which shall not afford an initial resistance greater than about six per cent. of the available pressure, with a metered by-pass, will prove ac-

ceptable on fire risks to both committees represented in this conference;" therefore,

This Committee respectfully present to the American Water Works Association full descriptions, with diagrams accompanying, of the two devices which are appended hereto, with the suggestion that either or both of same be tried on private fire service lines with a view to obtaining full experience as to their operation under practical working conditions; and that the respective water works submitting these devices to such trial will report the results of such experimental use to this Committee prior to the next annual convention of this Association.

Your Committee further recommend that Messrs. Tilden and French be extended the privilege of the floor at this convention, and that they be invited to further explain the character and merits of their respective devices referred to above.

Your Committee would further report that in addition to the foregoing, it has had under consideration the subject of standardization of thread for hose couplings, etc. Mr. F. M. Griswold, Chairman of the Committee on Standard Thread for Hose Couplings of the National Fire Protection Association, requested that our Committee also confer with the above named Committee on the subject of establishing a standard thread for fire hose couplings; and as we deem this an important matter in connection with the fire protection service, we granted the request so made, and have made our conclusions thereon the subject of a separate report which will be presented as a supplementary report of this Committee to this Twenty-fifth Annual Convention of the American Water Works Association.

Respectfully submitted,

C. H. Campbell, Chairman,
A. E. Boardman,
Geo. H. Felix,
Morris R. Sherrerd,
F. W. Shepperd,
Committee.

Mr. Campbell: In connection with this report, as I see that Mr. Tilden is in the room, and also Mr. Robinson and Mr. Blauvelt, and as Mr. French has empowered Mr. Robinson to represent him at this meeting, I move that at this time Mr. Robinson be given the privilege of the floor to explain the details of Mr. French's invention; and that after Mr. Robinson has finished and the discussion is over in that direction, that we hear from Mr. Tilden, who upon my invitation as Chairman of the Committee has with him some copies of plans of his device for distribution among the members. These will be handed to you here now so that you can better understand his description of the design shown.

Mr. Campbell's motion that Mr. Robinson, representing the National Fire Protection Association, be invited to take the floor and explain a device to be used to meter fire service lines, was now put by the Chair and unanimously agreed to.

President Sherrerd then introduced Mr. W. C. Robinson, representing the National Fire Protection Association, who said:

Mr. President and Gentlemen: I am sorry that Mr. French did not find a more worthy representative, but inasmuch as he was uncertain as to whether he himself or Mr. Blauvelt could be here, he sent the papers to me and asked that I present them to you.

The ideal meter for fire service would be one in which there was no friction loss and one which would register all of the water passing through it. It is, of course, impossible to obtain this ideal as we must necessarily suffer some loss by friction, but we believe that this loss can be kept so low that it will not be objectionable and that we can register all of the flow of water. It may not be considered necessary to accomplish this, much as the committee action would indicate.

I will read Mr. French's description of the device that he has presented to the committee.

FIRE SERVICE METER

DESIGNED BY THE INSPECTION DEPARTMENT OF THE ASSOCIATED FACTORY MUTUAL FIRE INSURANCE COMPANIES.

This meter is a development of the familiar meter system consisting of a weighted check valve in the main pipe with a small indicating meter in a by-pass around it. This indicating meter records at all times the flow of water through the by-pass. Water is prevented from running backward through this indicating meter by small check valves. A strainer of generous proportions protects the indicating meter works from obstruction, and is so arranged that the debris that is collected is washed out by every large flow through the main check valve.

The main check valve is provided with two concentric seats with the annular space between them open to the atmosphere. Any leakage past either seat in either direction is indicated at once by a discharge of water from this space. It is evident that since the area included by the larger seat is acted on by the pressure existing ahead of the clapper, this pressure may be reduced considerably before its effect on the clapper will equal that of the original pressure back of the clapper acting on the lesser area included by the smaller seat. When this occurs the rubber-faced clapper will leave its seat and will take a position dependent on the amount of water passing at the time.

When a small flow occurs the water passes through the indicating meter, which records the quantity on dial A, and then through the opening for the horn to the main pipe again. The clapper remains on its seat as the quantity increases until the pressure ahead of the clapper is reduced by the loss of pressure due to friction or other causes in the by-pass to the amount at which the clapper leaves its seat.

The horn or regulating valve moving with the clapper

enters the opening provided for it and reduces the quantity of water passing through the by-pass to one-tenth of that passing the main clapper, and is shaped so that it maintains this proportion constant for all larger flows through the device. By a simple mechanism, dial B is thrown into action when the clapper leaves its seat, and records what water passes the main check valve by multiplying the measurement of water through the by-pass by the constant coefficient—ten. Dial B is thrown out of use when the clapper is reseated, and the total flow passes through the by-pass again.

When the clapper leaves its seat, the force acting to keep it there during the small flows is destroyed and a weight is provided to assist the clapper in closing.

The principal results accomplished by this device are as follows:

1. Small and large flows are measured accurately.
2. Excessive friction loss is avoided.
3. A clear passage for large flows is assured.
4. Indication of the tightness of the main check is given.
5. Indication of the rate of consumption is given, that is, whether the consumer takes large or small quantities at a time.
6. An efficient strainer is provided which is kept clean automatically.

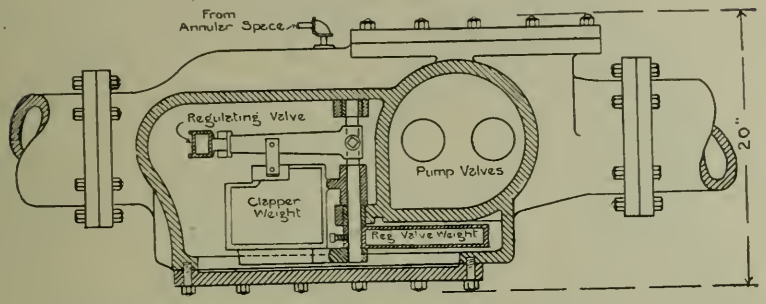
The loss of pressure as determined by the experimental meter which has been set up and tested at Lowell, Mass., is 5.2 per cent. of the static pressure when the clapper leaves its seat. The loss then drops at once to about 1 pound and gradually increases with the flow.

500	gallons	gives	1.6	pounds	loss.
1,000	"	"	3.4	"	"
1,500	"	"	5.5	"	"
1,800	"	"	8.0	"	"

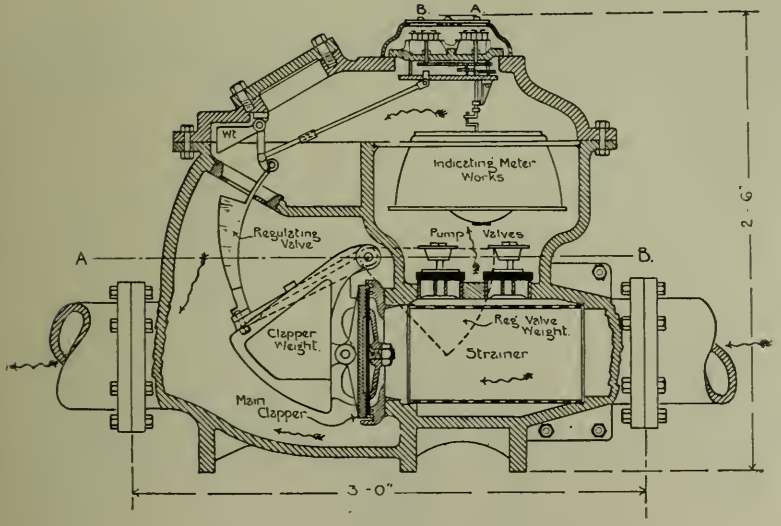
This record compares favorably with the best current meters on the market.*

The measurement of small flows up to, say, 125 gallons per minute is made by a 3-inch disk meter of some standard form and the accuracy of this meter is well known. For all

larger flows it has been shown that a registration between 95 and 100 per cent. can be maintained up to the full capacity of the pipe, and tests extending over several months have



SECTION ON A-B



FIRE SERVICE METER.

shown no material deviation from this condition.

President Sherrerd: Mr. Tilden will explain a design of a somewhat similar nature which will accomplish the same purpose of measuring flows through fire service lines.

Mr. Tilden: Mr. President and Gentlemen: I will first read the following brief descripton of the

HERSEY DETECTOR METER.

This device is called the "Hersey Detector Meter." Its object is to measure accurately drafts up to about 150 gallons per minute, and to detect and exhibit the flow of any additional quantity in excess of the above amount.

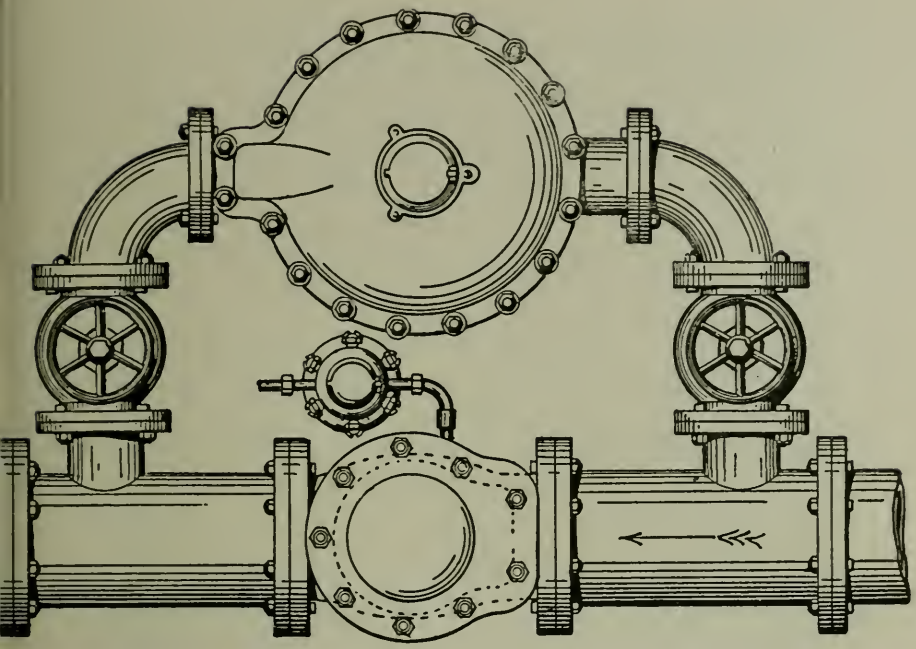
The device consists of a check valve in the fire service main and a meter on a by-pass around it. There is no mechanism in the main pipe except the check valve, which offers no objectionable resistance, and gives a practically unrestricted water-way for use in case of fire.

What the detector does, is, first, to cause all drafts up to about 150 gallons per minute to go around through the by-pass meter, where they are all measured; second, to give a positive indication that while this is going on the check is closed; third, to give a positive indication if the draft exceeds 150 gallons per minute and about how many hours such an excess has been going on and, if desired, to indicate about when it took place.

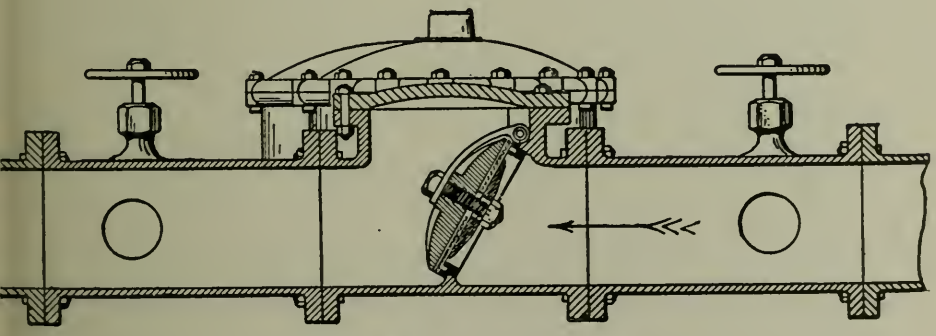
The device is furnished completely assembled so that it may be set as one piece in the main pipe line. It may be assembled so that the by-pass will be on either side of the main fire line, or on top or underneath, if more convenient. The by-pass is controlled by valves so as to permit inspection of the meter without closing the fire line. In case it is desired to use the whole device in place of the main yard check, the valve on the mill side can be a check valve.

The main check valve is provided with a differential seat which, with the by-pass, gives an initial resistance of about 6 per cent. of the available pressure. When the by-pass meter is delivering about 150 gallons per minute, the friction loss through the meter reduces the back pressure on the check to the equalizing point and any draft, in excess of 150 gallons per minute, unseats the check and finds unrestricted passage through it.

The moment the check leaves its seat a small amount of water flows from the differential seat to the atmosphere



6 inch Detector with 3 inch metered by-pass.



HERSEY METER DETECTOR.

through the small indicating meter and this meter will continue to run as long as the check is off the seat.

The check is so weighted that it will close when the flow drops somewhat below the flow which caused it to open.

The device will therefore accurately measure all leaks or ordinary small drafts, will give unrestricted water-way for use in case of fire, and will detect and show if water has been used in very large quantities, giving an approximate idea of the length of such use, and of about when such drafts occurred.

This, in brief, is a description which has been handed to your committee. Possibly some of the members will be interested in a more detailed description. The interesting thing from a water works standpoint, I apprehend, will be the question, how does the water works superintendent know that the main fire line is closed? That is to say, how does he know whether the check valve is tight and that no water is leaking by it?

If you will please refer to the lower cut, you will see an indication that the seat of the check valve is grooved; that is, that it has an annular recess. You will also see an indication in the upper cut that this groove connects with the atmosphere through the small meter. The check valve in closing the main line closes this annular groove or recess, which, as I have just stated, leads to the atmosphere. Therefore, it follows that if the main line is closed, the annular space is likewise closed, and if the annular space is closed there can be no opening or leakage to the atmosphere, and there will be no water running through the small meter. Conversely, then, if there is no water running through the small meter it is because no water can get into the annular groove from the inlet side or the check valve; neither can any water get into the groove from the outlet side of the check valve. Hence, if no water is running through the small indicating meter, it must necessarily follow that the check valve is tight. Thus you may be just as well assured that the check is closed to the passage of water as if you had a regular gate on the main line.

Now then the annular groove performs another office.

From the fact that there is a way open to the atmosphere it follows that there is a load on the top of the check valve equal to the area of the annular groove. This acts as a temporary or initial load or stick, as it is technically called.

The advantage of this arrangement over the weighted check valve is that just as soon as the valve opens, the load instantly disappears; that is, you get an initial stick, and initial load, which immediately the valve is open disappears. We have substantially agreed with the insurance engineering experts that there may be an initial stick of about 6 per cent. of the available head. Now then, if we have an available head of 100 pounds, 6 per cent. of this, of course, would be 6 pounds per square inch; and if we undertook to load the valve, say a 6 inch valve, with a weight equivalent to 6 pounds per square inch of area, there being approximately 28 square inches, it follows that we would have to put on a load of about 170 pounds, whereas by having this small area open to the atmosphere, we have simply a clapper of standard construction moderately weighted, obviously a considerable advantage, and with the further advantage, as just stated, that when the valve opens the load disappears.

The object of the little meter connecting with the annular groove is to indicate, first, if the main line has been opened; and, second, to indicate how long is has been open. By the use of a recording gauge, if you please, you may go further; you will then know if the valve was opened, and, if so, just when it was opened, and how long it remained open.

You will see that the general theory of this device is that the by-pass meter will measure all ordinary drafts. It seems rather peculiar to say "ordinary drafts" when there should not be any drafts at all. Right on that point let me say it is the general consensus of opinion both of our underwriting friends and our water works friends, that fire service should be independent from commercial services, that there should be no water whatever used from these fire services except for fire. Nevertheless, there have been perhaps some rare instances where water has been used where it ought not to have been used, and our water works friends think that they ought to have some means of knowing if the water has

been used, and how much has been used. Water may be used through the fire service in testing sprinkler heads, in making a small tap unknown to the manager of the factory, and in tests of one kind and another. The by-pass meter will accurately measure all such flows up to, we will say, 150 gallons per minute; in other words, it will detect and charge for petty larceny. If you discover from the indicating meter on the check that water has been going through the main fire line, it is time then to look into the matter, because wholesale robbery has been going on, because water must have been used in very large quantities.

The reason why the water taker seems to be averse to a fire pipe meter is largely because of the hostility of our insurance friends to anything whatever in the shape of a meter on the main line. Whether or not their reasons are well founded has been pretty well thrashed over before in these conventions, and as they have come together with us, and talked the thing over with us, we are inclined to be more reasonable and to think that their reasons may be pretty well founded after all; that is to say, that even meters of the current type may possibly become blocked, and obstruct the water way.

They think that in the case of a fire where a very large amount of water is used, accumulations in the mains for miles back may be forced into a meter and cause obstruction; so that we have followed along the line indicated as far back as 1897 by Mr. French, before the New England Water Works Association and again by Mr. Blauvelt at Detroit; that line being that the least objectionable obstruction that can be possibly put on a fire line could be a check valve of a detecting kind, and with that in view we have produced the device which is before you.

I thank you very much for your kind attention.

At the suggestion of Mr. Campbell, President Sherrerd now called on Mr. Blauvelt to take the floor.

Mr. Blauvelt: Mr. Chairman and Gentlemen: I quite agree with both of the speakers who have just addressed you, that it is highly probable that the most practical solution of this entire problem will be found to be in the combination of an indicating check and a meter by-pass. I think that the sense of the Joint Committee, which is very well chosen in its personnel, is very distinctly that a solution of the whole problem is to be found in an indicating check with a meter on a by-pass. Whether the meter on the by-pass does all of its work direct along the plans outlined by Mr. Tilden, or whether the other method suggested by Mr. French is adopted, it seems to me is more a question for the water works people to consider than the insurance people. The organization that I represent is interested up to and not beyond the point of having a clear water-way, with no more initial resistance at the outset of a fire than we are bound to have as frictional resistance at the time of a large flow for a fire.

So far as my own familiarity with this work is concerned, it is a good deal more in the line of Mr. Tilden's work than in the line of Mr. French's. At the same time both men are very intelligent and capable, and the matter of the difference in the metering method is not a point that I, as an underwriter, am so vitally interested in. I think there is not the slightest doubt but that you have had in the last two years enough combined knowledge and experience on this subject to very thoroughly exhaust the state of the art. I do not think there are any new or additional principles worth considering and I do not believe there is any hope for the future except to be guided by the wisdom and work of the Joint Committee. (Applause.)

President Sherrerd: This matter is before you, gentlemen, for discussion. I know the committee on insurance will be glad to have further discussion on the subject.

Mr. Campbell: In order that the matter may be in proper

shape for further discussion I move, sir, the adoption of the Report of the Committee on Fire Insurance.

Which was seconded and unanimously agreed to.

President Sherrerd: The matter is open for discussion, if you care to continue it.

Mr. Hague: It seems to me that this matter has been brought up on the proper line, that is the line of detection rather than that of prevention. But of course it must not be forgotten that it is very hard to devise a game which it is impossible to beat, and without going into unnecessary details, I see a point or two in which this particular game can be beaten. But just so soon as that happens it will simply stimulate some further investigation and a little further invention, and then after a while the device will no doubt be perfected and the question brought down to an irreducible minimum where we can keep pretty close track of the operation.

A man who will steal water in the absence of a detective device, will naturally try to beat a device just as soon as he comes in contact with one. Even now, on fire lines, without meters or any means of telling what water goes through them, they can be so arranged as to have no outlets whatever, excepting at the sprinklers, have the pipes so arranged as always to be available for inspection their entire length, and then kept under close inspection by the water works authorities so that it can be known when the pipes are tampered with. I think, however, that this invention of Mr. Tilden's is a long step ahead, and that the mechanical detector will greatly help the human detector in finding out what the results have been. One of the good points of this detection idea is having the small loss of pressure permitted, for by this detail, if a large meter, say the full size of the main pipe, is put into the by-pass, then in many cases probably a fair number of fire streams could be used and have all of the water metered, the resistance of the meter being low enough to prevent the opening of the check valve. In fact I see no particular objection to having the main normal supply for fire service go through the metered by-pass, with the idea that if the meter becomes obstructed so that a loss

of 6 pounds pressure will occur, then the check valves will open and the fire service be furnished through the main pipe.

I had a case in my own practice which is likely not novel or new, but may nevertheless be of sufficient interest to mention here. It was a factory fitted with a sprinkler system, and the sprinklers were provided with supply pipes directly from the mains in the street; the point where this sprinkler supply pipe left the street main was arranged with a manhole of brick so that the tap could always be seen by an inspector. From this manhole to the factory wall the supply pipe was incased within a regular cast iron pipe of a larger size, so that the water supply could not be gotten at without considerable work and trouble and chance of detection. Once within the factory the sprinkler supply pipe was always in sight and easily accessible so that it could be readily inspected, and the pipe was arranged with absolutely no side outlets, so that if at any time an inspector saw a "T" or other connection in the line of the pipe from which water connections could be supplied he would know at once that something had been changed, and that a chance at least for robbery existed. After this was put into place and checked up as all right, the municipal authorities were warned to have their superintendent or inspectors keep an eye upon the outfit from time to time, to guard against "accidents."

Secretary Diven: I would like to ask if either of those devices are so far perfected that they are ready for the market; and if so, if there is a price on them? I would like to find out what the cost is of installing either of those systems.

Mr. Hornung: As I understand the explanation of the device given here, it will largely depend upon the service of the detector, and as Mr. Hague has already pointed out, any one that will steal water will have ingenuity enough to beat the detector.

It was stated by the inventor that in the operation the detector is required to be open to the atmosphere; it occurred to me when that explanation was given, that it would be a very simple matter to plug the open end of it, which would make the apparatus inoperative, and practicable to

steal water. When the desired amount of water was so taken the plug could again be removed, leaving the device in a condition to perform its expected functions. What is there to give the water works superintendent information whether or not the apparatus has been tampered with in that way? Will Mr. Tilden be kind enough to explain how the water works man will be protected in such a case?

Mr. Tilden: I apprehend that it is pretty difficult to get a machine that you cannot beat, especially if the other man is a Chinaman. The particular type of indicator which I have shown here is, as you see, a meter which, as the gentleman says, is open to the atmosphere, but there are other devices which can be used, if you please, the broad principle of the apparatus being simply that there shall be some means of indicating whether or not the check is, or has been open. If our friend who has just spoken has had the experience of running up against such bad men as he is telling about, it is a perfectly simple matter to have, as I show in one of my diagrams, a device consisting of a small diaphragm, which when the water is on through the detector will become ruptured, thus showing that water has passed by the seat. That may be at the outlet side of the indicating meter. It would not be easy to repair, because it would be underneath the bonnet, where it would be inaccessible, thus stopping a man from effectually cutting off the meter. He might do it at the outlet, but the opening would exist underneath the bonnet, and the meter would go on indicating just the same.

Mr. Boeh: What is the cost of the installation?

Mr. Tilden: The general theory of the cost of this apparatus is that it ought not to exceed the cost of the corresponding size of current meter. That is to say, in the six-inch size the list price of the several current meters on the market is, I think, $350. Therefore, the cost of this combination of a six-inch detector and three-inch metered by-pass will not be in excess of the corresponding size of meter. We have other sizes besides the six-inch. These may be made up in all kinds of combinations; as, for example, the one illustrated is a six-inch detector with a three-inch metered by-

pass. If you wish to get a larger registration before opening the main line, it may be accomplished by using the larger meter on the by-pass. Thus with an initial pressure of 100 pounds, six per cent. differential, there would be 185 gallons measured by a three-inch meter before the detector opened, 340 gallons by a four-inch meter on the by-pass, and 480 gallons by a six-inch meter on the by-pass. With a six-inch meter, for example, you can use say two fire streams without opening the detector at all. It is anticipated that combinations will be made suitable for local requirements.

Before taking my seat I wish to express my thanks to the Fire Insurance Committee for their consideration, and especially my appreciation of their very earnest, long and painstaking effort in the direction of endeavoring to ascertain how this most important problem can be handled.

A Member: This by-pass in your device is just a regular meter?

Mr. Tilden: Yes, sir, a regular meter. The drawing is to scale and shows a three-inch disk meter.

A Member: So you can take two streams on it without opening the check. Would not the Fire Insurance Companies object to that, the same as they did if we don't have a check?

Mr. Tilden: The check is there to be opened instantly, providing the by-pass becomes clogged, which would seem to cover that point. The loss of head is exceedingly low. In the combination illustrated, at 1,000 gallons per minute, it is 1.7 of a pound loss; at 2,000 gallons, 2.2 pounds loss; at 2,500 gallons, 3.3 pounds loss.

Mr. Meyers: I would like to ask whether with a vertical form of meter, it would not tend to form an air chamber in the top which would interfere with the registration of the detecting meter?

Mr. Robinson: I cannot say as to that. I saw the meter taken down and put together; it had air in it at that time, and we operated it without any trouble. Perhaps Mr. Tilden can explain that. I think that air was carried out. I do not know as to that point yet.

Mr. Tilden: The air would be carried out if the device was operated up to its capacity.

Mr. Meyers: I mean with a small volume of water.

Mr. Tilden: There would be no difficulty so far as measuring the small streams is concerned—none whatever. The question might arise possibly in the proportional measurement after the device was open, as to whether that would be performed accurately so long as the air remained there; but in the course of time air would be carried out. It is not a serious question. You cannot hold air there indefinitely. It will gradually get out, especially through the stuffing boxes, or the indicating train.

Mr. E. V. French: (by letter) This matter of pocketed air has been given considerable attention, and in this design the indicating meter and the regulating valve will be submerged whenever water passes the device.

Mr. Boeh: Suppose that the water is heavily charged with earth and sand. Such water always gives trouble with small meters. This meter only working when water is used surreptitiously might become clogged, and thus not register when it was most needed.

Mr. Tilden: Do you refer to the by-pass meter?

Mr. Boeh: Yes, I mean the by-pass meter.

Mr. Tilden: I suppose that would be subject to precisely the same conditions to which any other meter would be subject where you have it set on a service that is rarely used. If you experience trouble of that kind, I do not know why it should be materially less.

President Sherrerd: If there was no draft at all through the pipe, the settlement of mud would be more likely to occur in the larger pipe rather than in the by-pass, so that the conditions would be more favorable for the small meter to operate than it would be for a meter on straight lines. If you use a meter at all, you will have some difficulty.

Mr. Boeh: Continuous use and regular monthly examination only, would enable the department to judge whether water was used. In this instance the consumption would take place at long intervals and examinations

not being made, because not deemed necessary, the meter might not register when water is used.

Mr. Boardman: Should the by-pass meter become so clogged as to not register, it would raise the pressure, and should the water be required on the other side, it would raise the pressure and open a check valve so suddenly and so completely that the water would be indicated by the detector check, and in passing the main check it would be indicated, if not actually recorded. That is part of the service that we expect of this small meter.

While I am on my feet I wish to remind the association that Rome was not built in a day. A perfect device to accomplish the object that we have in hand cannot be perfected by a mere drawing, or by the first few meters or devices made on theoretical lines. I do not think that either of the gentlemen who have presented these devices would for a moment contend that they have reached the acme of a device for that purpose. They appreciate the fact that perfection must be a matter of growth. They ask us to aid them to attain their object by a trial of some of these devices, and by pointing out to them the defects which may be discovered in practice; and for that purpose the recommendation of the committee was made that we do co-operate with these gentlemen, and the committee, in testing these devices and by reporting what defects arise. Any engineer present can pick out something that will strike him as apt to cause some trouble; but let us before criticizing have a little more experience in the use of these devices, and let us co-operate to find out what the defects are in practice ,and we will find that the manufacturers of these devices, and other manufacturers of devices, will thus more quickly attain the desired end. (Applause.)

President Sherrerd: The Committee on Insurance referred to a supplemental report on the matter of standardization of hose threads and steamer nozzles. We would like to hear that report.

Mr. Campbell: Before proceeding to read this report, I desire to say briefly that the matter that is the subject of this report did not originate with the American Water

Works Association, and in making this report I wish to say that it is not our desire to steal some other man's thunder. The National Board of Fire Underwriters and the International Association of Fire Engineers have been working on this proposition for a number of years, and have collected a great deal of data from which these conclusions were drawn. The substance of this report is taken from calculations and statistics carefully prepared and gathered from all over this country by, not only the National Board of Fire Underwriters and the Internaional Association of Fire Engineers, but also from our associate members, manufacturers of fire hydrants. Of course, the fire chiefs number among their associate members manufacturers of hose, steam fire engines and similar appliances carrying hose threads. Of course, we have set out a little more fully in our report how we came to take up this matter, but I wish to say in compliment to Messrs. Griswold and Bruen, of the National Fire Protection Association, that it was through them that our committee took up this matter. Mr. Griswold brought it to my attention, as I shall show you later, and the conference and the work between us has been very pleasant and very agreeable.

I will proceed to read the report:

SUPPLEMENTARY REPORT OF THE COMMITTEE ON FIRE INSURANCE ON THE SUBJECT OF STANDARD THREADS FOR HOSE COUPLINGS, ETC.

To the American Water Works Association:

Gentlemen:—In the report of the Committee on Fire Insurance which was submitted to the American Water Works Association to-day, covering the subject of meters on private fire service mains, reference is made to the fact that this Committee has been requested to consider the subject of a standard thread for hose couplings in conference with a committee on standard thread for hose couplings of

the National Fire Protection Association; and herewith represent that on April 24, 1905, your Committee held a conference with the above mentioned committee in the rooms of the National Board of Fire Underwriters, at which the following were in attendance, viz.:

Morris R. Sherrerd, President American Water Works Association;

F. M. Griswold, Chairman Committee on Threads for Hose Couplings of the National Fire Protection Association;

A. E. Boardman, of the American Water Works Association;

R. J. Thomas, of the American Water Works Association;

F. W. Shepperd, of the American Water Works Association;

Geo. H. Felix, of the American Water Works Association;

G. E. Bruen, Member of Committee on Standard Thread for Hose Coupling of the National Fire Protection Association;

William A. Anderson, Vice-President of the National Fire Protection Association;

C. H. Campbell, Chairman of the Committee on Insurance of the American Water Works Association; A. P. Smith, of the A. P. Smith Mfg. Co., Newark, N. J.; Fred S. Bates, Rensselaer Mfg. Co., Troy, N. Y.; J. F. O'Brien, Manager of the Valve Department of Fairbanks Mfg. Co., New York, N. Y.; E. Kennedy, of the Kennedy Valve Co.; W. H. Haughton, representing the same concern; Millard F. Smith, of the Ludlow Valve Company, Troy, N. Y.; W. C. Foster, of the Glamorgan Pipe Foundry Company of Lynchburg, Va.; W. J. Huxley, representing M. J. Drummond & Co., New York; Edmund F. Krewson, representing R. D. Wood & Co., Philadelphia, Pa.; D. F. O'Brien, of the A. P. Smith Mfg. Co., Newark, N. J.

Voluminous data were presented to the Conference from both the National Fire Protection Association and the manufacturers present who were associate members of the American Water Works Association, which fully convinced the Committee that it was very desirable and almost absolutely necessary to have a standard thread established;

and after thoroughly analyzing the situation and taking note of the many different threads in use throughout the country, it was decided that the thread best adapted for general universal service, and one which could be most quickly adopted and brought into service, at least expense was the seven and a half threads to the inch on a coupling having an internal diameter of two and a half inches and an outside diameter of three and one-sixteenth inches; and in order to more thoroughly cover the specific number of threads for the different sizes of hose couplings, we submit as a part of our findings the following letter addressed to this Committee, viz.:

New York, May 3, 1905.

National Fire Protection Association,
Committee on Standard Thread for Hose Couplings,
F. M. Griswold, Chairman, Geo. E. Bruen, H. C. Henley.

To the Committee on Fire Insurance,
of the American Water Works Association:

Gentlemen:—In view of the fact that the National Fire Protection Association has appointed the undersigned as a Special Committee to formulate "A Standard for Hose and Hydrant Couplings," for fire service, we beg to submit for your consideration and to urge the adoption of the following specifications and details as covering the most practical and acceptable conditions for such standards:

Inside diameter of hose....	2½″	3″	3½″	4½″
Number of threads per inch.	7½	6	6	4
Male Couplings:—				
Outside diameter of thread.	3 1/16″	3⅝″	4¼″	5¾″
Depth of thread.....	.0955	.1243	.1243	.1765
Diameter at root of thread.	2.8715	3.3763	4.0013	5.3970
Clearance between male and female threads.....	.03	.03	.03	.05
Length of threaded male end	1″	1⅛″	1⅛″	1⅜″

The above to be of the 60° V thread pattern with the one-hundredth inch cut off the top of thread, and one-hundredth inch left in the bottom of valley in 2½-inch, 3-inch and 3½-inch couplings, and two-hundredths inch in like

manner for the 4½-inch couplings and with ¼-inch blank end on male part of coupling in each case. Female ends to be cut ⅛-inch shorter for endwise clearance. They should also be bored out .03 inch larger in the 2½-inch, 3-inch and 3½-inch sizes, and .05 inch larger in the 4½-inch size in order to make up easily without jamming or sticking.

The specifications as here submitted are in accord with those presented at the conference meeting held in this city on the 24th ultimo, when this Committee had the privilege of the counsel and advice of your Committee and its associates, at which time the following resolution was unanimously passed and placed upon the minutes of the Conference:

"That it is the sentiment of the conference between the Committee on Standard Hose Thread Coupling of the National Fire Protection Association, the Committee on Fire Insurance of the American Water Work Association, and also the invited Associates of the American Water Works Association and manufacturers of fire hydrants, that the thread of 3 1-16 inch outside diameter (2½ inches inside diameter) with 7½ threads to the inch, is the thread that we would agree upon as the one most practicable and one that should be adopted for the universal use of the Fire Protection service."

It is perhaps needless to here present in detail the statistics which were presented at the Conference referred to, as this Committee is satisfied that the same have had your mature consideration, and that the further study thus had has but served to make more evident the absolute necessity for harmonizing the wide divergences shown in those documents as now existent throughout the country; we, therefore, appeal to you to secure from your Association as a body its approval of the "standard" as above presented in detail, and so unanimously accepted by the highly representative body which attended the Conference on this subject.

We appreciate very highly the knowledge that your Committee, and we also trust your Association as a body, realize the absurd incongruity existing under present condi-

tions throughout the country in relation to hose and hydrant connections, and we trust that in this appeal for a standard we may be assured of your hearty co-operation, to the end that the day may soon come when any community may be enabled to successfully render aid to its fellow community when the time of distress and disaster threatens them.

The object of this appeal is to bring the responsible powers and thinking public to a realization of their obligations to their fellow men, and thereby broaden the field of our usefulness, while at the same time, such unity of action will serve to reduce the fearful waste of national wealth which is sacrificed to the demon of fire each year. It is worth the best efforts of all the combined powers which may be either in official and controlling position or be interested as public spirited citizens of this great country.

We know of no organization which can throw more weight and influence in the accomplishment of this much to be desired result than the American Water Works Association; your approving sanction will carry conviction to all who may object; and such approving action will mark your Association as among the benefactors of mankind.

May we have your support in this worthy effort?

F. M. Griswold, Chairman,
G. E. Bruen,
H. C. Henley,
Committee.

At a meeting of the Committee on Fire Insurance of the American Water Works Association held in Parlor B, of the West Baden Springs Hotel, on May 8, 1905, suggestions, made in person by Mr. F. M. Griswold and Mr. G. E. Bruen, of the National Fire Protection Association, and Chief Canterbury, Chairman of the Committee on Standard Thread for Hose Couplings of the International Association of Fire Engineers, were considered and the following resolution was adopted as the sense of the Committee, and is herewith recommended for the approval of the American Water Works Association, viz.:

We recommend for adoption the following specifications and details covering a practical and acceptable standard, viz.:

Inside diameter of hose....	2½"	3"	3½"	4½"
Number of threads per inch.	7½	6	6	4
Male Couplings:				
Outside diameter of thread..	3 1/16"	3⅝"	4¼"	5¾"
Depth of thread.....	.0955	.1243	.1243	.1765
Diameter at root of thread.	2.8715	3.3763	4.0013	5.3970
Clearance between male and female threads.....	.03	.03	.03	.05
Length of threaded male end	1"	1⅛"	1⅛"	1⅜"

The above to be of the 60° V thread pattern, with one-hundredth inch cut off the top of thread and one-hundredth inch left in the bottom of valley in 2½-inch, 3-inch and 3½-inch couplings, and two-hundredths inch in like manner for the 4½-inch couplings and with ¼ inch blank end on male part of coupling in each case. Female ends to be cut ⅛ inch shorter for endwise clearance. They should also be bored out .03 inch larger in the 2½-inch, 3-inch and 3½-inch sizes, and .05 inch larger in the 4½-inch size in order to make up easily and without jamming or sticking.

Your Committee would further state that while making our investigations leading up to the above recommendation, we were struck with the equal importance and desirability of recommending for adoption a standard nut to be used upon the operating stem of hydrants and the auxiliary valves of the same, together with the nozzle caps; and also with regard to the weight of the couplings to be employed in the hose connections themselves; and we would suggest that these two matters be referred to this Committee for conference with other organizations in the same way as has been done with the standardization of hose thread couplings, to endeavor to also standardize these important auxiliaries.

Respectfully submitted,

C. H. Campbell, Chairman,
A. E. Boardman,
Geo. H. Felix,
Morris R. Sherrerd,
F. W. Shepperd,
Committee.

Mr. Campbell: Mr. President, Mr. Griswold, Chairman of the National Fire Protection Association Committee, is present with us. He has given this matter a great deal of thought, and has been very zealous in his efforts to bring about the standardization of hose thread, and I would be very glad to introduce him, and I think our Association also would be glad to hear from him.

Mr. Boardman: Before entering upon that, allow me to make a suggestion. Some of the audience have left, many of whom would doubtless desire to hear more fully upon this matter, and certainly the gentlemen whom you request to address them would like a large audience, as this is a matter of very great importance for this Association to take up.

I would therefore move that we postpone the discussion on this head until after the lunch hour.

President Sherrerd: We have a rather long program, and I dislike to depart from it at the first session.

Mr. Campbell: With all due deference to Mr. Boardman's suggestion, which however has not received a second, I feel in regard to this matter as I did while at the conference meeting, that while we are on the subject I would like to go right ahead while we are in working trim.

President Sherrerd: If there is no objection, we will be very glad to hear from Mr. Griswold, the Chairman of the Committee on Standard Hose Thread of the National Fire Protection Association.

Mr. F. M. Griswold (Chairman on Standard Thread for Hose Couplings, of the National Fire Protection Association): Mr. President and Gentlemen:—It seems that in reaching an opening I have to fall into the practice of using aphorisms, I do not care much for them, and if I use them at all I usually manufacture them. But there is one illustrious man who sat in the chair of the President of the United States who said, "This, gentlemen, is a condition and not a theory." It has been a condition for over thirty years, and during this period it may be said that the subject has been reported on by one or more associations almost every year, but the range of thought has never fallen

twice in the same channel in any one of the twelve or fifteen reports that have been made since 1873, when the subject was first brought up before the then National Association of Fire Engineers, now the International Association of Fire Engineers, which is represented by Chief Canterbury here to-day.

We had all the knowledge during the past eighteen months of many willing neighbors coming to help some city in distress having to cut their way through a veritable Chinese wall, and this Chinese wall, while encompassed within the space of one linear inch is more impregnable than the original Chinese wall which was put up to keep out enemies. In this country we have provided another plan which serves to keep out our friends, due to the fact that the lack of uniformity in hose threads and couplings is such that our closest neighbors cannot help us. St. Paul cannot help Minneapolis; New York cannot help Baltimore, and the situation was the same in Rochester. Your nearest neighbors cannot possibly come to help you, willing though they may be.

It is the belief of myself and of the Association which honored me in selecting me as Chairman of this Committee, that the time is now ripe to establish "a standard" for hose thread couplings. We have had a sad experience in past times and we could name a hundred towns and cities in this country that only await the psychological moment when they will be as Toronto, Baltimore or Rochester found themselves to be, in dire distress and yet without available help.

The idea and intention of this Committee is to establish "a standard." The practical question as to what that standard shall be does not to us make a bit of difference. The important thing is first to establish "a standard." As Horace Greeley said, "The way to resume is to resume," and to make headway in this business we desire to get rid of trifling. We desire to make "a standard." The one indicated may not be considered as absolutely the best one, and we may not succeed in finding the best one at the start; but let us now plant the seed or we cannot expect the har-

vest which will come more quickly, more easily, once we have made a beginning.

Now, looking around over the chaotic condition of affairs which has preceded us in the same effort, we try to reach a conclusion as to what would be the most rapid, least expensive and the best applicable to all conditions. Each member of the Committee has had his individual ideas as to what should be the standard thread, but we harmonized our differences and came to this conclusion. In 1891 the National Association of American Fire Engineers had a very excellent report submitted to them by a gentleman named Landy (not a fireman), in which this very matter of standardizing threads was brought up. Very much to our pleasure and satisfaction, when we came to look it up, we found that the author in his report showed a varied range of threads in use in some 1,600 towns, giving details as to the outside diameters of the threads, and reaching the conclusion that using 3 1-16-inch outside diameter as a basis, that anything between that as a minimum and 3⅛-inch as a maximum outside diameter could be brought to harmonize with 3 1-16-inch outside diameter, and that a proper tap and die could be used to cut a 7 or 8 thread down to the same diameter of the outside of the threads, and thus you have the combination whereby 7 threads and 8 threads get a sufficient bite to make a connection through the use of a swivel end or female 7½ thread coupling, and this connection would serve in 70 per cent. of the towns and cities in the United States.

Now, out of that lot of statistics there are 1,339 towns in which you may adopt 7½ threads. That is about 70 per cent. of the total number recorded up to the time of this presentation.

Messrs. R. D. Wood & Co. show up to 1905 581 towns, of which 52.6 per cent. have connections which can be formed and used on a 7½ thread basis, which is the one most wise to undertake as a standard and one that would incur the least expense and the least trouble. Its adoption will establish a standard. It is a good mechanical combination; all of the stresses and strains have been figured

on it, and we think if we can secure the endorsement of this association, we do not see why we have not thereby established a standard. We will have to grow up to a standard some day, and this is the most propitious time at which to make a beginning.

Appreciating the valuable assistance afforded us through the action of your Committee on Fire Insurance, we trust, gentlemen, that you will give your assent, as an association, to this, our petition, to the end that all people may "rise up to call you blessed." (Applause.)

Mr. Campbell: I think it would be well if we could hear from Mr. Walter Wood, one of our members, who has taken up this matter in a practical way.

Mr. Wood: I think we have had thoroughly impressed upon us the lessons of a large fire which Mr. Griswold has so fully placed before us which of itself emphasizes the fact that we should have a standard. I think that is the one question for us to think about; the number of threads to the inch and the diameters of the nozzle and other various details are entirely secondary.

What is needed is a standard, so that every town can give to every other town all the fire assistance that it is called upon to render. I have not followed out the details thoroughly, because I have left it to you as practical men to furnish the information to the committee as to the number of threads to the inch, or the diameters of the nozzle, etc. but I take it for granted that that committee has carefully digested all the various material that has been before it, and if they suggest a thread such as is covered in their report, I think that the business-like thing for this association to do is to adopt their conclusions, which have been drawn from such a multitude of varying sizes and diameters of threads, that one is bewildered with the mazes to which they ramify, and I hope you will adopt the standard that they have laid before you. It is a *standard* that we want, and I think the committee can be safely trusted, and that if adopted it will prove the wisest way out of the difficulty. (Applause.)

Mr. Campbell: We have with us a gentleman who has aided us in bringing about this conclusion and who has worked in unison with us—Chief Canterbury, of Minneapolis, who is chairman of the same committee for the International Association of Fire Engineers.

President Sherrerd: If there is no objection, we will be pleased to hear from Chief Canterbury. (Applause.)

Mr. Canterbury: Mr. President and Gentlemen: I want to say that I am much pleased with the progress that has been made by my friend Griswold and the other committees that have been at work upon this question of hose thread. The International Association of Fire Engineers has bothered with this question of thread for the past fourteen years. We have never been able to accomplish anything. As to whether we will at this time or not remains to be seen; but at the same time there never was as good a spirit in the work and as much progress made as during the time that these committees have been at work. Not as much progress has been made in the past five or ten years as has been made since September last, and every indication points to the fact that we are now going to be successful in getting a standard hose thread adopted.

That is the main question. As my friend Mr. Wood has stated, we can take care of minor particulars afterwards; and when it is presented it will be presented to you in such a way for adoption that I believe that your association as well as my own will not hesitate for one moment in taking up the subject and approving of it.

The 7½ thread is light—no question about that part of it—but we must take into consideration that one of eight is still lighter. When you go as high as 10, it is very cumbersome. Seven and one-half will take hold of 70 per cent. of our cities throughout the United States with very little work; and we feel in asking you to-day to adopt 7½ that we will make no mistake in adopting that as our standard.

I thank you, Mr. President. (Applause.)

Mr. Campbell: I move, Mr. President, the adoption of

the report of the Fire Insurance Committee recommending the adoption of the standard thread suggested.

Which was seconded and unanimously carried.

On motion, the convention adjourned until 2 o'clock P. M.

FIRST DAY—AFTERNOON SESSION.

The convention met pursuant to recess, President Sherrerd in the chair.

The Publication Committee not being ready to report at this time, the chair called for the report of the Committee on Past President's Badge, Mr. L. N. Case, chairman.

Mr. Case not being present, the secretary, in response to the inquiry from the chair, stated that Mr. Case had forwarded him a design for past president's badge, which, after examining, he had returned to Mr. Case at his request.

Mr. Cook, a member of the same committee, stated that he had received a communication from Mr. Case, and that he had requested Mr. Case to select a suitable design, and that he would approve anything which Mr. Case would get up. Mr. Cook, however, had heard nothing further from Mr. Case, and expected that he would be in attendance on the convention and bring the design with him.

The matter was passed for the present, President Sherrerd suggesting that the secretary endeavor to get into communication with Past President Case by wire.

President Sherrerd called for the first regular paper of the afternoon, which was submitted by Mr. Rosamond.

After reading and discussion of Mr. Rosamond's paper, President Sherrerd next introduced Mr. Charles A. Hague, who read a paper.

President Sherrerd: Gentlemen, there is one more matter on the programme for consideration by this convention, and that is the discussion of the amendments to the Constitution as offered at the last convention. The proposed amendments are printed in the proceedings of the last meeting, the suggested changes being in italics. I think the secretary is sufficiently familiar with the questions that were discussed at the last convention to give you an idea

of just what the suggested modifications were intended to accomplish, without going into the full subject of the modifications.

The secretary was about to read the proposed amendments when Mr. Maury suggested that because of the few members present it would be well to postpone acting upon the same at this time.

On motion of Mr. Hill, the consideration and discussion of the proposed constitutional amendments was deferred until Wednesday morning.

Secretary Diven read the following telegram:

Denver, Colo., May 9, 1905.

William R. Hill or J. M. Diven,

American Water Works Association:

Lake Cheeseman Dam, highest masonry dam in the world, storage capacity thirty billion gallons, for Denver's water supply, filled and water commenced running over spill-way this morning. Kind regards to all members of the association. W. P. Robinson,

Manager Denver Union Water Company.

Secretary Diven: I think that Mr. Hill knows something about that dam.

Mr. Wm. R. Hill: If I had known that this subject was coming up I would have been prepared to fully describe this structure. I visited this work while it was under construction and found it being built in an ideal location. The dam is on the South Fork of the South Platte River. It is of solid stone masonry founded upon granite, across a cañon which is only thirty (30) feet wide at the bottom and at a heighth of ninety (90) feet it is only one hundred and thirty (130) feet wide. The dam is two hundred and seventeen (217) feet high and seven hundred and ten (710) feet long at the top. It is built on a curve of a radius of about four hundred (400) feet.

The reservoir thus formed has a capacity of about thirty (30) billion gallons and a depth of two hundred (200) feet against the dam. The watershed covers an area of about one thousand eight hundred (1,800) square miles and its physical conditions are such that lead me to believe that the

water will be of excellent quality. The city of Denver is to be congratulated upon the completion of a structure so necessary for its welfare.

On motion of Mr. Maury the secretary was directed to return to Mr. Robinson acknowledgement and congratulations on behalf of the association.

On motion, a recess was taken until 10 o'clock Wednesday, May 10, 1905.

SECOND DAY—MORNING SESSION.

Wednesday, May 10, 1905.

Convention met pursuant to adjournment, President Sherrerd in the chair.

President Sherrerd: The first thing on the program will be the consideration of the amendments to the Constitution, which were laid over from yesterday. The secretary will give a synopsis of the proposed changes, nearly all of which I would say were suggested by the Executive Committee last year to cover what had come to be the actual practice on many points, but which seemed to be somewhat contrary to the wording of the Constitution. One especially suggested change that comes to my mind was that the Executive Committee be given power to change not only the time, but the place, of the annual meeting if they found it necessary to do so. That was discussed very fully last year, and it was because of the situation the association might have been placed in if Baltimore had been selected for the meeting. The conflagration there would have made it impossible for the convention to assemble, while the Executive Committee would have been, according to the present Constitution, without authority to make a change in the place of meeting.

Secretary Diven: This matter was published in the proceedings of the last convention, which you have already had opportunity to see. I think your attention was also called to the changes in one of the circulars sent out from the secretary's office. The part that I read will be new.

President Sherrerd: Unless there is objection to the new matter that the secretary is reading, we will pass on all of

the different articles after he has presented them, unless some point comes up by way of objection.

Mr. Campbell: I would suggest that, inasmuch as the Executive Committee have considered some of these amendments, it might be well to state which of them have been approved by the committee.

President Sherrerd: The whole matter was approved by the Executive Committee. The principal reason that action was postponed last year was because it seemed wise to allow it to go before the entire membership in the published proceedings, and also because at that particular session in which they were brought up last year there were but few delegates present. There is nothing to which the Executive Committee or any member has raised objection since the proceedings were printed. So I think it is quite proper to proceed, if you see fit to adopt them. It requires a two-thirds vote.

Mr. Campbell: I think it is well for us to have that information.

Secretary Diven: Amendments to any of these amendments can be proposed now from the floor.

Secretary Diven then proceeded to read the proposed amendments to the Constitution, as set forth on pages 85 to 95 inclusive, of the last annual report.

In connection with the proposed amendment as printed in the annual report, as Section 3, Article 3, of the Constitution, the following discussion took place:

Mr. Campbell: It seems to me advisable, having noticed the practical operation of corporate membership in some other associations under a different title, where it has worked out very successfully, by the admission, for instance, of other organizations in the same way that this American Water Works Association is an active member of the National Fire Protection Association, that we might receive such members and permit them to send a delegate to our convention, having the privilege of the floor and entitled to one vote. That has occurred to me from the fact that certain other associations have endeavored to co-operate along certain lines of fire protection interests, such as

the Fire Insurance Underwriters, the International Fire Engineers, etc. We could receive them under the corporate membership clause to include fire associations, National, International or State, State Waterworks Associations and the National Fire Protection Association or other associations of a kindred nature. This would in a measure increase our membership and at the same time would put us in direct co-operation with these different organizations. I make the motion, Mr. President, for the sake of drawing out the ideas of members on that subject more than anything else. I am not wedded to it as a fixed idea. At the same time it strikes me as a good thing; and I move that the associations as outlined by me be included in this corporate membership.

President Sherrerd: Under the Constitution, I would like to say that it would be proper for such amendments to be submitted in writing to the Executive Committee.

Mr. Campbell: That being the case, then it would have to lay over until the next meeting of the Executive Committee, would it not?

President Sherrerd: It seems so, particularly as this article was adopted last year. Anything else that is before the association in the way of amendments might be amended from the floor now, except this article which has already been adopted. If you make a new section to this article, it ought to be submitted in writing.

Mr. Campbell: Suppose I give notice now of my intention?

President Sherrerd: I think it would be proper then to write it out and submit it to the Executive Committee, to be acted on as another section.

Secretary Diven: This section concerns corporate active membership. It could not name associations very well. The idea of this clause is that when water departments or companies appoint new superintendents their names may be substituted on our books for those of their predecessors. We are in this section establishing a provision that will enable them to do that. For instance, if Mr. Smith is today superintendent, and the political complexion of the

board changes, and Mr. Jones, who is of the right political stripe, takes the office, then we change the name on the books from Mr. Smith to Mr. Jones, at their request. The change that you propose would require an additional clause.

Mr. Campbell: I will leave it in that shape, and give notice.

Mr. Rosamond: While you are on that subject, I would ask, for the information of myself and possibly other members, how would that work in case the superintendent pays his own initiation?

President Sherrerd: He retains his active membership.

Secretary Diven: If he has joined as a corporate active member, a superintendent can, if he desires, still continue his membership. I would state that we passed that section last year in order to get new members. I got only one of this class.

Secretary Diven then completed the reading of the proposed amendments.

President Sherrerd: The parts read by the secretary embody the changes in the Constitution as considered by the Executive Committee and recommended to the association for adoption. What is your pleasure?

Mr. Campbell: Mr. Chairman, I move the adoption of those changes in the Constitution as recommended by the Executive Committee.

Which was duly seconded and carried unanimously.

Secretary Diven read the following letter:

Office of

Geo. W. Fuller,

Hydraulic Engineer and Sanitary Expert,

170 Broadway, New York.

Mr. J. M. Diven,

Secretary American Water Work Association,

West Baden, Ind.

My Dear Sir:—It is with much regret that I find I am unable to attend the convention, owing to professional en-

gagements which I cannot postpone. I am sorry not to be with you. I have not been able to prepare a paper concerning water softening for municipal supplies and about which, as I wrote you some weeks ago, I had hoped to say a few words informally at the meeting.

However, this aspect of municipal water supply is one which is beginning to receive attention in this country, and about which more will be heard in the future. It will not be long before there can be presented at a meeting of the association some account of the new municipal water softening plant at Columbus, Ohio, plans for which have just been completed preparatory to a letting early in June.

Wishing you a most successful meeting in every way, and again expressing my regrets at my inability to attend, I am, with greetings to the members of the convention,

Very truly yours,

GEO. W. FULLER.

Secretary Diven: Mr. Nagel, of the Hayes Manufacturing Company, wishes to state that any member calling at their booth in the rotunda and leaving his address, will receive a copy of a picture styled "The American Waterworks Beauty." I have seen the young lady and she is worth going after.

President Sherrerd: We will take up the regular program, reading and discussion of papers. The next one on the list is "An Additional Supply of Water for the City of New York," by Past President Wm. R. Hill.

Paper read by Mr. Hill and discussed at length by several members.

At the request of President Sherrerd, Third Vice-President Rowe took the chair temporarily.

Vice-President Rowe: The next paper will be "Notes on the Density, Relative Volume and Weight per Cubic Foot of Pure Water," by Mr. M. L. Holman.

Secretary Diven: Mr. Holman is not here. The paper is printed in the advance copies of papers which have been in the hands of the members for some time. It is full of tables and formulæ and it will be a rather difficult paper

to read. I will therefore read it by title and anybody desiring to discuss it may do so.

This paper has been acted upon by the Publication Committee and will be included in the proceedings. Any discussion of it now or by letter hereafter is in order.

Vice-President Rowe: We have a volunteer paper by Mr. P. A. Maignen, of Philadelphia, Pa., who will now address you.

Mr. Maignen presented his paper calling attention to the principal features of it, after which the association proceeded to the election of officers for the ensuing year and the selection of the place for holding the next convention.

The secretary made the usual announcement, that active members only were entitled to vote for officers, but that the associate members had a vote on the place for holding the convention.

President Sherrerd resumed the chair and called for nominations for the office of president.

Past President Campbell, after calling attention to the great importance of the selection of the officers of the association and its bearing on the future success of its work, presented the name of Mr. B. C. Adkins, of St. Louis, Mo., for president, which nomination was seconded by Mr. A. E. Boardman.

There being no other nominations the secretary on motion of Mr. Keeler cast the ballot of the association for Mr. Adkins, the motion being carried by a rising and unanimous vote.

President Sherrerd announced the unanimous election of Mr. Adkins, and appointed Messrs. Campbell and Rosamond to escort him to the platform.

President-Elect Adkins: Mr. President and Members of the American Water Works Association: I certainly appreciate the honor that you have just bestowed upon me in electing me to this office, and I certainly appreciate one other thing, and that is that this position is not only one of considerable honor but one of hard work. The many problems that are brought before this association for solution and remedy devolve upon members the necessity of

allotting a certain amount of time, especially this year, to their consideration and adjustment, not only for the benefit of the people whom you represent, but also for the members associated with you.

It will be my mission during this administration to make it as successful as has been the past administration, and with the co-operation of all of the members I hope to accomplish it in such a way that I trust I will have merited the confidence that you have placed in me to-day.

I thank you, gentlemen. (Applause.)

President Sherrerd: The next order of business will be nominations of vice-presidents. There are five to be selected, no two of whom can be from the same State.

Mr. Felix nominated Mr. Charles E. Rowe, of Dayton, Ohio, which nomination was eloquently seconded by Mr. Boeh, of Cincinnati, Ohio, and there being no further nominations the secretary was, on motion of Mr. Jones, instructed to cast the ballot of the association for the unanimous election of Mr. Rowe as the first vice-president of the association for the ensuing year. The ballot was accordingly cast and Mr. Rowe declared elected.

President Sherrerd: Nominations are now in order for second vice-president.

Mr. Caulfield nominated Mr. John B. Heim, of Madison, Wis., which nomination was seconded by Mr. Hill.

Mr. Keeler nominated Mr. Dabney H. Maury, of Peoria, Ill.

President Sherrerd appointed as tellers Messrs. Kennedy and Tucker, and a ballot being taken resulted in the election of Mr. Maury.

President Sherrerd, after announcing the election of Mr. Maury, called for nominations for third vice-president.

Mr. Hill nominated Mr. George H. Felix, of Reading, Pa., which nomination was dully seconded by Mr. Mather.

Mr. Milne nominated Mr. A. A. Tucker, of Memphis, Tenn.

President Sherrerd appointed as tellers Messrs. Kennedy and Rosamond, and a ballot being taken resulted in the

election of Mr. Felix, who was declared by the chair duly elected.

Mr. Caulfield nominated Mr. John B. Heim for fourth vice-president, which nomination was heartily seconded by Mr. Keeler.

Mr. Glazier nominated Mr. Howard A. Dill, of Richmond, Ind., which nomination was seconded by Mr. Alvord.

A ballot being taken resulted in the election of Mr. Heim, who was forthwith declared elected as fourth vice-president.

Nominations for fifth vice-president were called for and Mr. Diven nominated Mr. George J. Dunbaugh, which nomination was seconded by Mr. Dill.

Mr. Darch nominated Mr. Alexander Milne, of St. Catharines, Can.

A ballot being taken resulted in the election of Mr. Milne, who was declared elected as the fifth vice-president.

President Sherrerd called for nominations for members of the Finance Committee.

Mr. Gwinn placed in nomination Messrs. Keeler, Dill and Tucker and there being no further nominations they were on one ballot cast by the secretary unanimously elected.

Mr. Worrell thought that the South might not get all that it was entitled to and placed in nomination for secretary-treasurer John M. Diven, of Charleston, S. C.; the nomination was seconded by Mr. Rosamond, and there being no other nominations President Sherrerd cast the ballot of the association and John M. Diven was declared elected secretary-treasurer.

Secretary Diven: Mr. President, the secretary-treasurer is not elected to make speeches nor to talk, but to do the work. That is the way we do it in the South.

I trust that that lazy microbe that has been referred to as prevalent in the South will not get into my brain so that I will lose my capacity for work and not be able to keep up the work in the future as I have tried to do in the past. There is a great deal of work still left undone. I realize that possibly more than any of you. I am thankful to say

that I am rather more fortunately situated in the South to take hold of these details than I was in the North. I trust that those omissions which I have made in the past, for lack of time to keep the work up, will be supplied under better conditions. I thank you very much, gentlemen, for your approval of my past work. (Applause.)

Mr. Boardman: I would like to call attention to the fact that we are now as an association a member of the National Fire Protection Association, which holds a convention in New York on the 23d of this month. Having in view the glorious work which has already been begun, with regard to the standardization of certain parts of fire hydrants and couplings, we should appoint as a delegate to represent this association at the meeting of the Fire Protection Association the chairman of our own committee which has done such good work in the past. I nominate Mr. C. H. Campbell, of Charlotte, N. C., to act as our delegate and represent us at the meeting, or at any meeting during the coming year, of the National Fire Protection Association.

Which motion was seconded and unanimously agreed to.

President Sherrerd: We will now take up the selection of the next place of meeting. Please confine your speeches to a few minutes' duration. I will ask the secretary to read the invitations received, as only courtesy to those who have taken the trouble to forward them.

Secretary Diven read invitations received from Mr. Thomas Urquhart, mayor of Toronto, Canada, extending a cordial invitation to hold the twenty-sixth annual convention in that city; also from Mr. C. G. Trussell, manager of the Hotel Frontenac, Frontenac, New York, and from Walter J. Begby, chairman Convention Committee Board of Trade, Atlantic City, N. J.

Secretary Diven: Mr. Bemis, who unfortunately is not with us, wrote me that he took up the matter of an excursion on the lakes, the idea being of chartering a boat, as suggested by our president last year. This Mr. Bemis finds can be done prior to the 15th day of June, the boat being entirely at our disposal and to go to any ports on the lake that we want to. He does not say whether he will

insure us smooth water all the time—with a guarantee of 300 people, the expense to be $4 a day, including everything, board, meals and the use of the boat. Mr. Bemis probably would have more to say on that, but he is not present.

Mr. Campbell: I believe it is to the interest of the American Water Works Association, which is American in its scope and covers this entire country, to meet at Boston next year; the fact that the New England Association meets in Boston is no reason why we should not meet there. I believe that we will benefit by going there, inspecting the waterworks of the city of Boston, and showing to our Eastern friends, even though there may not be so many of them in that section, that we appreciate their membership. I therefore put in nomination the city of Boston for the convention of 1906.

Mr. Milne: I second the nomination of Boston, in which I take great pleasure.

Dr. Mason: I am from the city of Troy—of which Boston is one of the suburbs, therefore I am really speaking for my own when I speak for Boston. You may all see Troy as you pass by it. We have much to show you if you will only stop for a day and night, and if you men will only go to the Eastern seaboard during the coming year, I am sure you will cool off and have a splendid opportunity of seeing much that is of general interest. I very earnestly second Boston.

Mr. Kelley: Mr. Chairman, I hate to say a single word to prevent this convention deciding to go to Boston—I do not suppose they will decide to do anything else—because we have no trouble about taking care of Boston from New York. The only reason I rise is to move to postpone the selection of place of meeting until to-morrow morning, for the reason that there are not more than one-half of the members of the organization in attendance at this convention present at this meeting. The associate members are entitled to vote on this particular question, and it may interest them.

As to Boston, we do not seem to have any invitation from the officials, and it is possibly the best thing that we have

not, as the members will go there depending entirely on themselves and not expect any entertainment from the city officials. It has been customary in times past to hear from various sections of the country in reference to invitations, but I do not think this association need wait for that. I simply rise, Mr. Chairman, for the purpose of making the motion to postpone the selection of the place for the next annual meeting until to-morrow.

Mr. Caldwell: I move that the secretary cast one ballot for the city of Boston.

President Sherrerd: Before the motion is put, I would like to say for the information of Mr. Kelley, that the president requested one of the associate members to go down and announce that this matter would be considered at this time. I presume one reason why they did not respond is that they have already cast their ballot in Charlotte, N. C.

Mr. Campbell: I feel perfectly satisfied that Mr. Kelley is sincere in what he wants to do in this matter; but here is a suggestion. It is not our fault that we members are present and the others not here. They have had full notice, and the rest of us have stayed here. I think we ought to dispose of the question, and therefore I move that we proceed with the original motion.

President Sherrerd then put the question upon the selection of the city of Boston as the place for holding the next annual meeting—1906—and the same carried unanimously.

On motion, the convention adjourned until 2 P. M.

SECOND DAY—AFTERNOON SESSION.

Convention met pursuant to recess, and was called to order by Vice-President Rowe.

Secretary Diven read the application of George Becker, draughtsman in City Engineer's office, Seattle, Washington, which upon motion was accepted and the applicant elected to membership.

Mr. C. Arthur Brown, of the Marietta Water Works Laboratory, Marietta, Ohio, read a paper entitled:

"The Practical Sterilization of Public Water Supplies by Means of Copper-iron Sulphate and Filtration."

Vice-President Rowe: We have another paper bearing on this same subject, to be presented by Professor Caird. I think it better to have both papers discussed together, and if there is no objection that plan will be followed.

Professor James M. Caird presented a paper entitled "Some Experiments with Copper Sulphate."

After the reading and discussion of the above papers Vice-President Rowe announced the next paper on the program to be one by Mr. F. B. Leopold, "Filtration of Public Water Supplies in Relation to Typhoid Fever Epidemics."

After the reading and discussion of this paper the convention adjourned till 7:30 P. M.

SECOND DAY—NIGHT SESSION.

Wednesday, May 10, 1905.

The Convention met pursuant to adjournment, President Sherrerd in the chair.

The Wednesday evening session was devoted entirely to papers illustrated by lantern slides.

The program was opened by Secretary Diven, who caused to be thrown upon the screen pictures of Past Presidents of the Association, accompanying the same with running remarks, which were of an exceedingly entertaining nature.

An amusing incident of this exhibition was that just as Past President F. A. W. Davis, who reached the convention late, owing to poor health, entered the room his picture was thrown upon the screen. He had not heard the remarks introducing the picture and was considerably surprised.

He was followed by Mr. W. P. Mason, with "Sundry Notes on Deep-Seated Waters."

After which papers, illustrated with lantern slides, were read as follows:

"Turbine Engines for Water Works," by Mr. Dabney H. Maury, and "The d'Auria Pumping Engine," by Mr. Luigi d'Auria.

Both of these papers were discussed at length by many of the members and the hour was late when the session

broke up for the night.

On motion duly made and seconded the convention adjourned to meet at 10 A. M., Thursday, May 11, 1905.

THIRD DAY—MORNING SESSION.

Thursday, May 11, 1905.

The Convention met pursuant to adjournment, President Sherrerd in the chair.

On motion, the application of Mr. David E. Helferich, Superintendent of the City Water Works, Bloomington, Indiana, which had been favorably reported on by the Executive Committee, was received, and the applicant elected to membership.

Mr. M. N. Baker, Associate Editor of The Engineering News, New York City, presented the first paper of the morning.

President Sherrerd: Mr. F. W. Cappelen not being present, his paper, which has been received and printed in the advance edition of papers, will be read by the secretary.

REPORT OF PUBLICATION COMMITTEE.

To the American Water Works Association:

Gentlemen:—Your Publication Committee respectfully reports that it has held four sessions since the opening of the Convention, and has endeavored to review in advance of their presentation all of the papers submitted to the Society with such care and deliberation as limited time would allow.

In one or two instances papers have escaped the attention of the Committee owing to the lateness with which they have been presented; but such suggestions as the Committee offered upon these papers have been accepted by their authors and will be embodied in the final publication.

The general principle governing the Committee in its criticism of the matter submitted has been first of all to eliminate in accordance with the constitutional provision, so far as possible, all exploitation of patented devices or commercial articles; at the same time endeavoring to not

exclude a reasonable description of such protected articles as seemed to them to possess exceptional scientific interest or novelty.

The Committee further feel that a review of the papers of the last few years indicates that in future the character of the papers can be improved by the elimination to a considerable degree of personal reference whether these be in the way of business exploitation or personal aggrandizement.

Your Committee also believe that it would be to the very best interest of the authors of papers presented to this Association to so word the same that they may appeal to the understanding of their readers as being entirely devoid of any intention to advertise goods in the sale of which the authors might be interested, or to exploit individual achievements.

In this connection your Committee would respectfully suggest that future authors of papers for presentation at our annual conventions adopt the principle of writing in the third person singular, a regulation which for many years has been in force in many of the other important scientific societies of a nature allied to ours.

While your Committee recognizes that it is allowable to a moderate degree to intersperse papers of a more serious character with some few in a lighter vein, yet that this line of authorship can be overdone is easily seen; and it is, therefore, the province of the Committee to suggest that great care in the future should be observed in the admission of papers of only a social, reminiscent or humorous character. Were a very free rein given to the publication of such papers it is the belief of the Committee that the proceedings of this body would lose much of their value and dignity.

Your Committee feels that its work will not be fully complete without a careful revision of the discussions which have taken place, so that the principles which it has here endeavored to formulate can be applied to our published proceedings as a whole.

The work of the Committee has in some respects proved a delicate and a difficult one, and acknowledgement is due

to the authors of papers submitted for the readiness with which they have accepted suggestions which must at times doubtless have seemed ruthless and exacting.

In conclusion, your Publication Committee would suggest that its work cannot be thorough and efficient unless all papers be in the hands of the Committee at least thirty days in advance of any given convention; and if possible such papers should be submitted in duplicate. A uniform observance of this rule is vitally necessary to the proper review of the subject matter presented to this Society; and any failure to accord to the Committee this opportunity will work injustice not only to the Publication Committee and to the Society at large, but to the authors of papers as well.

All of which is respectfully submitted:

H. E. KEELER, Chairman,
DABNEY H. MAURY,
JOHN W. ALVORD,
J. M. DIVEN,
Committee.

Mr. Goodell: In rising to move the acceptance of the Committee's Report, I wish to say that it is one of the finest reports of the sort I have heard. The importance of such rules has been brought home to me during a connection with editorial work for something like fifteen years, during two years of the time under Mr. Charles Warren Hunt, Secretary of the American Society of Civil Engineers, on the publication of the "Proceedings" and "Transactions" of that Society.

If there is any one thing that this Association needs, it is to have its proceedings occupy a place in the literature of water works of the United States, which my good friend Baker says is still a howling void. The American Street Railway Association, which is much like our own, gets out annually a volume of transactions very carefully edited on exactly the lines suggested by our Committee. The transactions of the American Street Railway Association are one of the best parts of the working library of the presidents, managers, superintendents and engineers of the

street railway systems of this country, and in fact of the whole world. The reason they have this standing is because the Association has had a publication committee, which enforces the same kind of regulations that our Committee recommends, so that anything published by that association is known to be as free as five or six gentlemen can make it from any taint whatever of commercialism.

Another association exactly like this one, the National Electric Light Association, nearly went up the flume three years ago, because its publications were not governed by such regulations. Three years ago, recognizing that the Association was losing its prestige through the commercialism that was getting into its transactions, similar action to that suggested by your committee was taken, with the result that the society to-day prints a volume of transactions—just what this Association is going to print, I hope—which is absolutely indispensable to the stockholder, the director, the president and every one connected with lighting plants in this country.

Accordingly, gentlemen, it gives me a great deal of pleasure to move the adoption of this report.

The motion being seconded, carried unanimously.

Secretary Diven: I am in receipt of an application for active membership from Mr. Lewis M. Bancroft, Superintendent Water Works, Reading, Mass., who is also Treasurer of the New England Water Works Association. I ask the privilege of casting the ballot of this association for his election.

Which on motion of Mr. Rosamond was unanimously agreed to.

REPORT OF EXECUTIVE COMMITTEE.

To the Members of the American Water Works Association:—

Gentlemen:—It has been brought to the attention of your Committee, that in one State an opinion has been given by the Attorney General of the State that there is some misunderstanding as to the right of water commissioners to pay the expenses of its superintendent or other representa-

tive, to attend the conventions of this and other associations; and the President was authorized to confer with the Attorney General of that State in the matter, to see in what manner, if any, expenses could be properly allowed to delegates attending conventions of the American Water Works Association and other similar associations.

Your Committee has decided, and now rule that active members, who are also patentees, manufacturers or dealers in water works supplies or appliances, and who wish to exhibit them at the conventions, be also required to take out an associate membership. We do not believe it fair to the associate members to permit others to take advantage of the privileges that they pay for. This does not, or need not in any way affect the member's standing as an active member, which is necessary if he desires to retain and enjoy all its privileges, including that of holding office in the Association.

Your Committee have directed the Secretary to obtain prices for binding the Proceedings in a substantial form, to notify all members of the same, and on their request and the payment of the exact cost of binding and carriage, to have them uniformly bound for the members. We regret that the finances of the Association will not permit the substantial binding of all copies of the Proceedings.

Your Committee have examined the report of the Secretary-Treasurer and approved the same.

Your Committee received a proposition to print the Proceedings of this Convention, by giving the advertising privileges as pay for same; but we feel that this would to some extent take the control of the proceedings out of the hands of the Association, and do not recommend that the proposition be accepted.

Your Committee report with the greatest regret the death of three active members during the past year, viz.:

J. A. Marion, Civil and Mechanical Engineer, Montreal, Canada.

Col. A. M. Miller, U. S. A., Washington, D. C.

H. C. Stillwell, Providence, R. I.

Your Committee have placed the price of Proceedings to

non-members at three dollars.

Your Committee have fixed the salary of the Secretary-Treasurer at the same amount as last year.

Your Committee recommend that when the index of the complete Proceedings is published, it be published and distributed as a separate volume.

Your Committee recommend that the Committee on "Standard Specifications for Cast Iron Pipe" be made a Committee on Water Works Standards, and its membership be increased to seven, and that all questions on standard specifications and material be referred to this Committee.

Your Committee recommend that the scope of the "Insurance Committee" be enlarged to take in all matters concerning Fire Protection and the name be changed to Fire Protection Committee, and that the matter referred to in the President's address concerning the demands of the insurance people be referred to this Committee.

The President and the President-elect were authorized to confer, especially with the active members, with a view to placing the financial condition of the Association on a better footing.

Respectfully submitted,

M. R. SHERRERD, Chairman,
DABNEY H. MAURY,
BEN. C. ADKINS,
ALEXANDER MILNE,
A. A. TUCKER,
H. E. KEELER,
CHAS. E. ROWE,
J. M. DIVEN, Secretary.

On motion of Mr. Heim the report was adopted.

REPORT OF SECRETARY-TREASURER.

Number of members at close of last convention:

Honorary	7
Active	383
Associate	71
Total	461

Losses during year:

By resignation, Active	3	
By resignation, Associate	1	
By death, Active	3	7

Members at beginning of this convention.... 454

Of these five (5) Active Members are, with dues charged in advance for current year, three years in arrears; making the roll of members in good standing:

Honorary	7
Active	372
Associate	70
Total	449

Forty applications have been received to be acted upon at this convention for active membership and eight for associate membership; if these are all elected it will bring the total membership up to:

Honory Members	7
Active Members	412
Associate Members	78
Total	497

Received only one application for "Corporate Active" membership, which seems to indicate that the new class of membership is not popular, or is not thoroughly understood.

The results obtained in gain in membership by sending out free copies of the proceedings do not seem to warrant the continuance of this practice.

I believe that better results would be obtained by sending a circular or pamphlet setting forth the aims, objects and work of the Association and inviting the co-operation of all waterworks officials; such circular to be sent to every waterworks on the North American continent not now represented in the Association.

This would involve considerable expense and some labor, I believe that it will pay for both the expense and labor, and

will greatly increase the membership and usefulness of the Association.

Am working on a complete analytical index of the proceedings, and hope to have it ready for publication this year.

Only one order was received for a set of the reprint of the complete proceedings of the Association, while this is not encouraging, will this year make special effort to secure the required number of subscriptions, believing that such a complete reprint would be of great value.

FINANCIAL.

Receipts:—

Cash on hand June 6, 1904, date of last convention		$114.18
Received for initiation fees		295.00
Received for annual dues		1,941.00
Received from sale of proceedings		19.00
Received for advertisements in proceedings		537.00
		$2,906.18

Disbursements:—

Secretary, account salary	$498.34	
Printing advance copies of papers	36.15	
Postage	92.44	
Postage and express on proceedings	174.46	
Convention expenses, St. Louis Convention	43.85	
Printing proceedings	1,696.00	
Office expenses	126.69	
Expenses Insurance Committee	27.00	
Stenographer, St. Louis Convention	125.00	
Interest and discount	29.45	
Members' copies of papers	27.34	2,869.72
Balance cash on hand		$36.46

Bills for printing advance copies of papers for this convention and the convention badges have not been paid.

F. A. W. Davis: I would like to inquire of the Secretary,

do I understand that you state in your report that you were sending out bound copies as advertising matter?

Secretary Diven: I was authorized last year to send out not exceeding 300 copies to Water Works officials who were not members, as a means of inducing them to join the association. I did not send the full number out because the returns were very poor. I sent out about 200, on which the postage alone was nearly fifty dollars. I doubt if the members obtained in that way fully paid the postage.

Mr. Davis: I move that we concur in your recommendation that that be discontinued. I do not think that is right.

President Sherrerd: With his usual modesty the Secretary omits to state that his salary for even the year before last year has not been fully provided for; and it was with a view to cover this item, and also to put the Association on a better financial footing, that the President and ex-President wanted to take up this matter with the active members, thinking that the associate members have carried their share in the expense of several conventions. You will no doubt hear from us in the near future. The Secretary-Treasurer's report is now before the house.

Mr. Worrell: I notice that I am the only man here from Alabama. If the Secretary will send me some of those circulars he intends sending out, I will send one of them, with a personal letter from myself, to each Water Works superintendent in the State of Alabama. I think in that way we can get at least *one* more member, and probably ten or fifteen, from that State.

President Sherrerd: We would be glad to have other members do the same thing in their respective states, where the waterworks people have not been hitherto interested in the American Water Works Association. What will you do with the Secretary-Treasurer's report?

Mr. Gwinn: Did you say we had over $400.00 a year ago and only $36.00 now?

Secretary Diven: $114.00.

Mr. Gwinn: There is a falling off, then, a net loss of about $300?

Secretary Diven: That might be explained possibly by the fact that this convention is being held very near the beginning of the fiscal year, and there has not been as much collected up to this time as there usually is before the convention, which is usually held in the middle of June.

President Sherrerd: The amount due and owing to the Association is sufficient to cover all its outstanding obligations; but we ought to have some leeway beyond that to go on. It has been necessary during the past year for the Secretary-Treasurer to borrow money to carry on the Association work.

The question being now on the adoption of the Secretary-Treasurer's report, the same carried.

REPORT OF THE FINANCE COMMITTEE.

To the American Water Works Association:

Gentlemen:—Your Finance Committee would report that they have carefully examined the books, accounts, vouchers and other papers in connection with the finances of the Association, and in the hands of the Secretary-Treasurer, and we find them as well as the report of the Secretary-Treasurer correct as per his statement, to wit:

Statement of Assets at Close of Fiscal Year, May 6, 1905.

Receipts:—

Balance on hand, May 6, 1904.....	$114.18
Receipts for year ending May 6, 1905.....	2,799.00
	$2,913.18

Disbursements:—

As per vouchers Nos. 1 to 32, inclusive.....	$2,876.72
Balance cash on hand May 6, 1905.....	36.46
	$2,913.18

Assets Outstanding May 6, 1905.

Due from Active Members in good standing....	$622.00
Due from Associate Members.....	290.00
	$912.00

Due from Active Members owing for 3 years to

April 15, 1906	63.00
Total outstanding	$975.00
Active Members owing for two years to April 15, 1906	20
Associates owing for two years	3

Respectfully submitted:

H. E. KEELER, Chairman,
ALEX. MILNE,
Committee.

On motion of Mr. Heim the report of the Finance Committee was adopted.

President Sherrerd: We have completed most of the regular program, but there are several volunteer papers. We will at this time be glad to hear Mr. Charles' paper, "A Few Practical Hints."

Mr. Charles read his paper and answered many questions asked him, especially concerning the rapid rate of reading meters in Lexington, Ky.

At the conclusion of the discussion on Mr. Charles' paper President Sherrerd announced as the next paper "A New Method of Mechanically Operating Screens," by Mr. J. Ralph Van Duyne, Resident Engineer, Newark, N. J.

After the discussion on Mr. Van Duyne's paper President Sherrerd announced a paper by Mr. J. Waldo Smith, Chief Engineer Croton Aqueduct, "Methods Used to Increase the Progress of the Construction of the New Croton Dam." Which in the absence of the author was read by the Secretary.

Mr. John Ericson, City Engineer, Chicago, Ill., next addressed the Association, giving a history of the Chicago Water Works.

The Committee on Electrolysis then made its report, as follows:

On motion of Mr. Heim the report was adopted as read.

REPORT OF COMMITTEE ON ELECTROLYSIS.

PEORIA, ILL., May 1, 1905.

To the American Water Works Association:

Your Special Committee on Electrolysis begs to submit, as follows, its report:

During the past year there has been no important change in the legal status of the various electrolysis suits. The case of the City of Dayton vs. the City Railway Company, in which Judge Brown, of the Court of Common Pleas of Montgomery County, Ohio, handed down his decision in 1902, was appealed by the City to the Circuit Court. This Court, Judge Sullivan sitting, on December 22, 1904, handed down a decision practically confirming that of the lower Court.

So far as your Committee is informed, no decision has as yet been rendered in any other Court. Several suits are, however, pending, and several new suits are about to be commenced.

Your Committee can find nothing to change in the recommendations contained in its previous reports.

Respectfully submitted,

DABNEY H. MAURY,
J. WALDO SMITH,
G. H. BENZENBERG,

Special Committee on Electrolysis.

President Sherrerd: There is one other committee which we had hoped to hear from, of which Ex-President Case is Chairman—the Committee on Past Presidents' Badge. As I stated before, I understand there has been a design prepared and submitted to the members of the Committee. I think it is a matter that might as well be cleaned up, and as we can no doubt rely on Mr. Case's judgment as to the selection of the design, I would like to entertain a motion that the Committee be empowered to approve on behalf of the Association a design for a badge which may be procured and worn by the past presidents.

Upon motion, it was ordered that the Committee on Past Presidents' Badge be empowered accordingly.

President Sherrerd: One other committee that is on the list for to-morrow, that upon Uniform Annual Reports, of which I believe Mr. Caulfield is chairman.

Mr. Caulfield: Last December I wrote the members of the Committee, and asked one of them to act as Secretary. I did not hear from him until lately. He was so busy he couldn't attend to the matter. But I have consulted with the members of the Committee since my arrival here, and they are unanimously of the opinion that it is impossible to have uniformity of annual reports. Each department desires certain data in their reports that probably other cities would not desire. I understand there has been adopted uniformity of reports with reference to pumping, the duty of engines, and matters along that line; but this Committee, I believe, was appointed to devise or recommend some uniformity of reports so far as accounts are concerned.

The Committee have instructed me to make a report to the effect that the Committee does not think it advisable to secure uniformity of reports so far as the financial part is concerned, and they have asked me to recommend that the Committee be discharged.

Secretary Diven: I am sorry that the Committee has given up so easily. I believe that the object sought for, a uniform system of accounts, can be carried out. The

American Street Railway Association in connection with the National Electric Light Association, has taken up a similar idea and has devised a system of accounts which is quite generally used; and I believe if a proper system of accounts was devised and presented to the people, in the course of time it would be adopted and universally used.

Mr. Caulfield: I wish to state that one of the members of the Committee obtained considerable data last year, and it was with that in mind that I requested him to act as secretary, hoping that he would devise some plan. There was another member of the Association that was on the Committee last year, and he submitted, I think, an individual report, with forms and all that, which I think the Association adopted. He was not on the Committee this year.

Mr. Maury: I presume the Association is aware that "Municipal Engineering" at Indianapolis some years ago invited competitive entries of blank forms of all descriptions from waterworks of the various cities, and offered prizes. We sent in ours and won first prize. I did not believe that we were entitled to it. I know I was not entitled to any special credit in connection with it, because most of our forms were gotten up by my assistant, so I felt bound to divide the prize with him. As a result of that competition Municipal Engineering did get out, I think, and put on the market a set of standard forms for waterworks, including account books of all sorts. I presume this Committee has looked into that; and if not, I should think that, as long as that competition brought out several hundreds of entries, and as long as the compilation of results was made pretty carefully, it might be well, unless the Committee has exhausted the subject, for them to acquaint themselves with what was done by Municipal Engineering along that line.

President Sherrerd: I think it quite proper, if the Committee be continued, to ask them to go into matters of that kind, and to put the Committee on the same basis as other standing committees. The incoming President can then change the personnel of the Committee as he may see fit,

and perhaps we can get something. Mr. Caulfield, you have the floor.

Mr Caulfield: We have a set of forms in our city that we think pretty complete, as is evident by the fact that expert accountants who have examined the waterworks in other cities have applied to us for our blanks; in fact, we send our blanks all over the country; so that at this time we should not feel like changing forms that have been adopted after a series of years and as necessity demanded.

I was speaking to a representative from Indianapolis, who said that they would not want to change theirs. That is the difficulty that we are up against. Every waterworks department thinks that it has got perfect blanks. However, I will withdraw the request that the Committee be discharged, so that the President can appoint a new Committee.

President Sherrerd: If there is no objection the report will be received, and the Committee continued on the list of Standing Committees.

The President would like to ask that Mr. Ferguson, who is President of the Central States Water Works Association, be requested to join with him in interviewing the Attorney General of Ohio in accordance with the authorization of the Executive Committee as to the allowance of expenses of waterworks delegates to the convention.

That completes the program. I would like to suggest that we meet promptly at 2:30 o'clock, and devote at least an hour to the matter I mentioned.

At the close of this session President Sherrerd informally exhibited, and invited those present to view his very fine album of photographs of South American scenes, procured or taken during the recent tour of President Sherrerd through Brazil.

Among these was the view of the Aqueduct, resembling one of the old Roman aqueducts, which was built in Rio de Janeiro in 1744, for the purpose of conducting water into the city. It was a magnificent piece of engineering work built of brick and stucco, and is now being used in part for a street car line. President Sherrerd called attention to the

high development of the water supply question in South America, and the care taken by the people there in the collection of their drinking water supplies, the result being that they are almost entirely free in that region from typhoid fever epidemics.

On motion, the convention adjourned until 2:30 P. M.

THIRD DAY—AFTERNOON SESSION.

The convention met pursuant to recess, and was called to order by President Sherrerd, who then requested Vice-President Tucker to temporarily take the Chair.

The application of Mr. Charles Carroll Brown, Consulting Engineer, Commercial Club Building, Indianapolis, was read by the Secretary, and on motion the applicant was elected to membership.

Mr. Rosamond: I have two little matters that I would like to present to this Association. On the 29th of last month, we had a fire at six o'clock in the morning, and some time later during the morning, the Chief of the Fire Department charged inadequate pressure. We have an automatic recording gauge, and the record showed 120 pounds. There was only one hydrant within striking distance of the fire. We took that hydrant out inside of a few hours, as soon as we could after we found there was something wrong there, and the condition of the hydrant is exhibited by the photograph which I now show you. Its stem was bent, just buckled in this shape, and the nut that carried the gate could not rise above the first crook. It was

a gate hydrant. (A voice: "They must have turned it the wrong way"). Yes, they used a two foot wrench and undoubtedly turned it the wrong way, which we proved after an investigation lasting two evenings. The Chief of the Fire Department would not believe that his firemen could make that mistake; but after the investigation he was thoroughly convinced. I guess you have all seen the little verse I wrote, and which arose from this cause. (Here the speaker exhibited a bottle containing a thick pasty mass, and also a hardened cake of mud.) That is the kind of water we have to pump sometimes. I intended to bring with me and exhibit to you a little picture painted with that water, but I forgot it. It will actually paint. Here is the sediment that settled out of that water, which was taken right from the sand bar at the intake. The sediment in the basins when they were washed out this spring, was three feet deep in one of them. We pump into one basin and the water passes over a wall to another, and then over another wall to a third basin. It takes one week to settle. Mr. Amesbary has had to handle some of this water, and he knows all about it. It settles on a sand bar near the intake, and that is why there is sand present on the bottom of that specimen. That contains ochre due to the river passing over ochre beds. That water after a week's settling in the basins is of a milkish and very faint reddish tinge. That shows there is plenty of alkali in it. We get about all the mud out of it.

Mr. Gwinn: If you will wait until after the meeting, I will introduce you to some of the filter men.

Secretary Diven: I always supposed that Mr. Rosamond was a waterworks man. I think his case had better be investigated, to ascertain his eligibility to membership in this Association. I don't believe the stuff in that bottle is even wet. I should judge that the water if there is any is a by-product of it. You may get a little water out of it.

Mr. Gwinn: Mr. Rosamond wrote a little poem before he left home, and I think he should read it. (Cries: "Poem! Poem!") Mr. Rosamond is so modest that he will not read his own poem, so I am going to do it. It is as follows:

"When the mud is in the water, an' the frost is in the pipes,
An' the dear consumer's kicking, an' the Council's 'bout to strike,
An' the things you say so careful are sure to be misconstrued,
An' every one who meets you, thinks you very, very rude,
Oh, that's the time for you to hide way back in your den,
An' figure how you're coming out, an' where you are, just then,
When every one is howling, n' nothing seems just right,
When the mud is in the water, an' the frost is in the pipes.

There's a kind of bilin feelin' broke loose inside of you,
An' you want to cuss out awful, but you know you dassent to,
For the town is always full of fussy fightin' men,
Who will make you lots of trouble; (just to show you that they can)
An' the frost that's in the pipes brings great big trouble chunks,
An' the mud that's in the water, brings abuse in greater hunks,
That's when they try your patience, an' command that you get right,
When the mud is in the water, an' the frost is in the pipes.

Now, we've met here together; an' we'll have a jolly time,
An' the consumer left at home may kick until he's blind.
We'll greet one another as Bill and Dan an' Joe,
An' some will go the pace that's not considered slow.
We'll carry home new ideas, an' map out newer lines,
We'll forget about our troubles, in this good old summer time,
An' we'll go home feelin' frisky, an' fit for any life,
When the mud is in the water, an' the frost is in the pipes.

The Arkansas Traveler.

(Dedicated to the Water Men who take their supply from the muddy rivers of the West.)" (Applause).

Mr. Maury: I think that is after Riley—When the water is riley. (Laughter).

Vice-President Tucker: Mr. Diven suggests that you brought this before the wrong body, that you should have brought it before the Brickmakers' Association.

Mr. Rosamond: I should like to know if some other gentlemen have had experience with this hydrant proposition, of having them twisted off?

It appearing that there was no desire to further discuss this matter, the Question Box was taken up.

QUESTION BOX.

Secretary Diven read Question No. 1, viz.:

What is potable water? Some standard is desired; how many bacteria per C. C., how many degrees of color, how many parts of solids per million, what degree of hardness and alkalinity can a water contain and still be a potable or good commercial water?

Professor Caird was asked to answer the question.

Professor Caird: It would take a big book to answer that question in its several parts.

Secretary Diven: We are in the publishing business. If anybody wants to write a book, we will publish it. We must expect some answers to that at some other time. I will read No. 2.

Is it necessary to have cast iron pipe, pumping engines and other material for waterworks construction, tested at the foundry, shop or factory to insure good material and workmanship; if so who should pay for such tests, the makers or purchasers?

That should be respectfully referred to Charley Hague. I would state that that question was sent in before Mr. Hague's paper was received. I will read two questions of an allied character, only one of which is printed, viz.:

No. 3. Where a quick-acting valve is found to be necessary on a pipe line or distributing system is there any air valve or other device that will prevent or reduce the water hammer and injury to the system caused by the operation of such valve?

The other question which came in later is, "What is the best preventative of water hammer where automatic fixtures are used, or when caused by the sudden stopping of elevators?" They both come under the same head and may be considered together.

Mr. Keeler: I think Mr. Ross can give us some information on that.

Mr. Ross: With the consent of the Association I might say a word or two. If the member who asked the question was referred to me, I would be glad to take half an hour to answer him. I would suggest the use of a relief valve to take care of the hammer, of not too large area, and with a spring that will give the largest possible amount of movement with a slight variation. To get this result it would be best to double up or multiply the number of springs instead of using one very heavy spring. Adjust the springs to the pressure which you wish to hold in the pipe and cut it into a large number of small units, say one spring of large diameter and the remainder of smaller diameter, but about the same tension. Use three springs in a set one inside the other, and then place 6 or 8 of these sets in a circle. This gives the equivalent of a very long spring, which permits instant relief in case of water hammer. These are more particularly for the relief of shock on large water mains and have proved very effective.

Secretary Diven: This question was asked more particularly with reference to railway cranes, and applies to a 6-inch or 8-inch stand pipe, with a quick operating valve on it; where railroads take water without the intervention of a tank, would such a valve as that take care of the difficulty complained of?

Mr. Hollingsworth: The speaker has had a little experience recently along this particular line of appliances. There have recently been some locomotive cranes set up at Wabash and it was found that the standard pressure before any disturbance was made in the connection was 50 pounds; and when a locomotive would take a supply the pressure would drop to about 30 pounds; and when the relief valve or lever of the train would let go, it would close instantly

and the pressure run to 200. Air chambers were put on having a capacity of perhaps 12 cubic feet. These did not relieve it entirely. Then a 2-inch ordinary relief valve was put on, which reduced the pressure to 165 pounds. Beyond that we could find no relief until the railroad company took out the crane that they originally installed, and put in one that had a slow closing valve. The valve put in last was one that requires eight or nine seconds to close. After that the shock was not so serious—only about 135 pounds.

Mr. Ross: I might say the use of a reducing valve will assist in cutting down the shock from water hammer where they are liable to put on fire pressure on direct pumping system and a locomotive is liable to come up at the same time, it is very essential that a large valve should not be opened when the fire pressure is on. By means of reducing valve the pressure is cut down to 15 or 20 pounds. The locomotive has to wait possibly a minute or two longer, for water, but the situation is relieved very much. I would suggest that if you had put two 2-inch relief valves on your lines, it would operate to relieve your pressure much more than one, because undoubtedly if you had the ordinary type of water relief valve it would not give much opening or relief; and if you had a pop safety valve it would repeat the pulsation and increase the difficulty.

Secretary Diven: I think we all appreciate the fact that it is poor practice to set a railway crane directly on the mains. The proper way is to compel the railways to have tanks; but it is sometimes a little difficult to persuade them that that is right and necessary. Tanks are expensive to construct and maintain. They want direct connection, and the question is whether it is proper to give it to them or not.

Mr. Salmon: I was just going to suggest that water companies should not allow railroads to have direct connections on their mains for standpipes. We have had serious difficulty arising from drawing water in this way. In one case it came near being serious on account of fire. I think all private water companies are now pretty well agreed that it is dangerous and they will not allow rail-

road companies to connect up their standpipes direct with their mains. Water companies should try and insist upon this. It is dangerous to allow any direct connection larger than two inch, as in case of a fire in that district the pressure might be materially affected. If a railway company complains of the expense of erecting tanks and drawing the water from them, the water company should reply that where water is drawn direct from the mains, the price would be double over what they would charge if drawn through a tank. The economy to the railway company would then be considered. A 50,000 or 100,000-gallon tank watering thirty engines daily can easily be supplied with a one-inch connection to the main and with an automatic shut-off, the tank would be kept well filled all the time. A 1½-inch pipe would supply fifty engines daily from a 100,000-gallon tank and not interfere with fire pressure.

Vice-President Tucker: I fully agree with the last speaker on that, but in my own case those connections have been allowed, and that is the condition we find now existing. The question is how to get around that. They have been allowed and we cannot get them to abandon them.

Mr. Salmon: We had such a condition and we said: "If you want to have this, you must pay for it. If you will just put in a tank we will give it to you."

Questions Nos. 4 and 5 were now read by Secretary Diven as follows, viz.:

No. 4. How can cast iron water pipe, laid in salt marsh or other soil impregnated with sea salt, be protected from injury caused by the action of the salt?

No. 5. Is there any pipe better than cast iron for such places?

Secretary Diven: The two can very readily be discussed together. At the Chicago convention Dr. Mason gave us a talk on the trouble at Atlantic City, N. J., with pipes laid in salt marsh.

Mr. Maury: The first pipe put in was a steel riveted pipe, and was, I believe, installed against the recommendation of the engineer in charge. The second was a wood

stave pipe, put in under the successor of that engineer, but recommended by him.

Secretary Diven: I understood that the samples presented at the Chicago convention by Dr. Mason were cast iron.

The question next in order, No. 6, was read as follows:

No. 6. Has any member had experience with injury to pipes laid under railroad tracks, by reason of the vibration caused by passing trains, and how can such injury be avoided?

Mr. Davey: I had some experience with a 6-inch pipe formerly laid diagonally under a railroad crossing. For years I had trouble with the joints of this pipe, and was continually having the railroad tracks torn up and blocked so as to have the joints recaulked. About a year ago I abandoned this pipe and laid a new main straight across at right angles with the tracks. Since then there has been no leaks.

Mr. Salmon: I have had several pipes laid across railroad tracks—6½ feet deep—but have never had any trouble at any time.

Mr. McNamee: I had a 12-inch line laid eighteen feet below the rails broken square in two by the vibration. The only remedy found was to abandon it and lay around where the pipe was not subject to vibration of trains. The pipe had originally been laid in sand, and then the railroad fill had been put on afterwards. There was a large amount of rock and broken stone.

Mr. Salmon: I have laid a great many pipes under railroad crossings and many of them are now in use over twenty years without leaks. Pipes should be laid at least 6 feet under the track and filled with black dirt and ordinary gravel, not coarse. The jar will then be taken up. If filled with rubble stone or clay the jar is more liable to be carried to the pipes and the joints loosened.

Mr. D. W. French: We had some trouble with some 6-inch pipe laid under tracks several years ago. It was a cinder fill, and the vibration started leakage. We finally took these pipes up and relaid them inside a 12-inch wrought

iron pipe, passing the small pipe through it. This practice has been followed several times now and we have had no further trouble.

We have a 16-inch and 20-inch which crosses under tracks of the West Shore and Erie R. R. companies., (both double tracks), where a great deal of trouble was experienced for several years on account of the vibration when heavy freight trains passed over. In these cases we drove piles on either side of the pipe and two feet away from the sides of the pipe and practically six feet between centres. The piles were sawed off squarely and 12-inch x 12-inch yellow pine timber was used to support the tracks directly from the heads of the piles. Carrying the tracks from the piles, and thus removing the vibration from the pipes, seems to have cured the trouble.

Mr. Goodwin: We have in Kansas City a 30-inch pipe laid under the Union Pacific and Missouri Pacific railroad tracks, at a point where 57 tracks pass over it, through their main yard. This pipe was laid in 1887. There has only been two or three minor leaks in this line in the last five or six years. Previous to that time I do not think there had been any leaks. We have another 30-inch line laid three years ago. The first pipe I speak of was laid diagonally across the railroad tracks at an angle of about 30 degrees. The last pipe, laid a few years ago, was laid directly across the track and we have never had any leaks in this line. The first pipe referred to after passing under these numerous tracks also passed under the main line of the Great Western track for a distance of about 2,000 feet; and it has given a great deal of trouble. It was laid about 4½ feet under the ground, and the main line of track runs immediately over the pipe. The new line laid a few years ago ran up James street, parallel with the street railway tracks. We have recently laid a 30-inch line carrying a pressure of about 15 or 20 pounds on low service line supplying high service stations. We have a 20-inch line laid under this same system, that also passes under the Burlington and Santa Fe tracks, more than 100 tracks in all, carrying 135 pounds pressure at the station. This line has

been in twenty years and there has never been a leak in it reported. There is one 15-inch line, one 16-inch line and one 12-inch line that leads from our high service station, that passes under a network of tracks, something like 25 or 30 in number. In these lines we have never had any leaks, except in the 15-inch line during the flood of 1903. This 15-inch main gave way and ditched four sleepers, three locomotives and a few baggage cars, standing them all on end. It washed out a hole about 65 feet in depth. This was one of our lines under the railroad tracks. I think this is the only difficulty we have experienced with pipes under the railroad tracks.

Mr. Maury: Some mention was made just now of the Atlantic City pipe line. I think the previous question asked related to the protection of cast iron pipes laid in salt marsh. I stated that first a steel riveted pipe had been laid in place of the existing cast iron main, and second, that under a later administration a wood stave pipe had been laid parallel to this steel riveted pipe. There were several reasons why the former engineer, Mr. Hawley, did not wish to lay a cast iron pipe along the course which this pipe was to take. One urgent reason was that the pipe line paralleled the right-of-way of the trains coming into Atlantic City, which ran at very high speed, with the result that the salt marsh there quivered almost like jelly, and it was very hard indeed to keep the joints in the cast iron pipes. Another reason was, that a large main if made of cast iron would be expensive; another was, that cast iron, as had there been abundantly proven, was attacked by chemicals in the salt marsh. I believe that at the previous convention Dr. Mason said that the compound found on those pipes was sphagnum moss, and he said it was the result of the action of an organic acid that was developed in those swamps, and not of the soil itself. The fact, however, is that in spite of Mr. Hawley's recommendation, a steel riveted pipe was ordered laid by the council, and then it became Mr. Hawley's duty to see that that steel riveted pipe was protected in the best possible manner. The reports of Atlantic City will show the manner in which the

coating was applied, the kind of coating used, and the way in which the burlap was first wrapped around the freshly painted pipe, and then the burlap itself painted with coating. It makes an interesting description well worth any one's reading. Mr. Kenneth Allen, his successor, succeeded in having laid across the marsh parallel to this pipe a wood stave pipe, from which very good results are hoped, not only because like the riveted pipe it will be less liable to leak under the jar of trains, but also because it is hoped that it will be less affected by the chemicals in the marsh, which have proven so deleterious to the cast iron pipe laid there previously. Of course a wood stave pipe will not be an expedient that can be used to supplant small mains laid in cities under high pressure, as a rule; still because of its lasting qualities it is well adapted to resist leaks being caused by the jarring of passing trains.

Secretary Diven read Question No. 7 as follows, viz.:

No. 7. What is the most practical valve box for street gate valves and what style do you use in your city?

Also No. 8. Will electrolysis affect the main operating screw on gate valves, also the brass mounted parts?

Secretary Diven read questions 9 and 10 as follows, viz.:

No. 9. What system is used in your city or department to locate service pipes?

No. 10. What system do you use for filling street sprinkling wagons, special cranes or fire hydrants, and which do you consider the better?

Mr. Alvord: In some cities I examined I have observed the best system for locating service pipes seems to be the application of a good sized pick and shovel and two Irishmen.

Secretary Diven: I think, Mr. Chairman, that the information sought for by the proposer of the question is how to locate the shut off or curb box. There was no explanation with the question, but that I infer is the information sought for.

In the north in winter time it is not always easy to find the curb box, for it may be covered with several feet of snow. When it was my misfortune to be in the business

in a part of the country where such conditions existed a considerable part of the year, I took a measurement of the location of the curb box, so that it could be found at any time of year. I took two prominent points, usually the opposite corners of the building supplied, and ran two diagonal lines, making the curb box the point of meeting. With such a measurement it was easy to locate the shut-off at any time by using two tape lines and measuring from the selected base points. This was often of great use when the space between the sidewalk and curb was piled high with snow shoveled from the walk. And some such scheme would have been very necessary for those Kentucky lightning meter readers, and even with that help their progress would have been somewhat retarded, I fancy.

Has any member any similar method or a better one, something that will quickly and easily locate the stop when hidden under snow or mud? Our object is to help one another, and I think that answering such questions is one of the best ways in which we can accomplish that object, and make the association of the most value to its members.

Mr. Rosamond: I brought with me one of our records to answer that. It is nothing more than an index card, and on the card we have the service number, the owner and the consumer, and then the location of the tap and the location of the stop-box relative to the nearest corner. We find that very convenient.

Mr. Caulfield: We have a special standpipe with 2-inch tap and pipe drip valve below frost and valves on top that they can use in warm weather. When it becomes cold, the top valve is taken off, and then there is a rod which is attached to a second valve. We do not allow fire hydrants used at all.

Mr. Heim: We use a sprinkling valve which can also be used by the fire department. The sprinkling valve is attached to the nozzle with a hose coupling, standard thread, so that the fire department can use that same connection in case of fire. We have the water turned on to the hydrant during the summer. We have now adopted another valve with a wheel which can be attached and de-

tatched by the sprinkler when he wants to use it. It has a leather seat; there will not have to be any regrinding done as with the brass disc valves. Using the wheel instead of the hydrant wrench prevents the crowding of the stem or discs; the leather gasket can be easily replaced.

Vice-President Tucker: The fire plugs in our city are under the control of the fire department.

Mr. Heim: It is pretty hard, especially in cities, to prevent the use of hydrants for street sprinkling, especially when the city is on an elevation and is the owner of the waterworks. At Madison we tried to stop them from using hydrants, but it was impossible. We had to do something, so we adopted the sprinkler valve.

Mr. Charles: We object to the use of fire hydrants for any other purpose than putting out fires. We put special standpipes in at different parts of the city, and have meters for them and nozzles that come down from the standpipes at the top and discharge directly into the sprinkling carts. They haul and distribute from their wagons and pay for it, by meter measurement.

Mr. Gwinn: At Terre Haute we have a special connection for street sprinkling, a 2-inch main with a meter on it, and a valve on top to control it. Lately our folks purchased some of those street flushing machines. Perhaps you gentlemen have had experience with them. The street flushing is done by wagons under air pressure, a large tank like a coal oil tank, with a smaller tank under the driver's seat, in which there is maintained an air pressure of about 40 pounds. I do not believe in the use of fire hydrants for that purpose. We made an arrangement with the city, whereby they agreed that the city would not use fire hydrants for any purpose except to extinguish fires, and if they wanted water for any other purpose we would send a man to open up the hydrant, making no charge for the service of the man or for the water. But when it came to flushing the streets, it was necessary to make some provision, and I made an arrangement for one year to allow them to use the fire hydrants with the proviso that the city employes are not to open hydrants, but we are to send one

of our men. We employ one man for that particular purpose. He puts an auxiliary valve on the fire hydrant when they have to fill three or four wagons from that one point, and opens up the hydrant; we do not allow the city officials to touch the hydrants in any way. That is only an experiment so far which was begun about a month ago, and I do not know just how it is going to turn out; but I think that as long as we control the hydrants, we ought to be able to keep them in pretty good repair. I do not believe that the mere fact of opening and closing a hydrant is going to wear it out. The hydrant, properly constructed, ought to stand being opened a good many times, especially as we have an auxiliary valve that will make it unnecessary to open the hydrant more than once in two or three days. The fact that we have our own employe to open the hydrant looks as if we would be on the safe side, but I will be apt to know more about that next year.

Secretary Diven: I have just received a letter from Cleveland, Ohio, viz.:

I regret to say that I shall be unable to attend the meeting of the American Water Works Association. I hope you can arrange to have the next meeting on the lake, the terms of which I have written you.

Very sincerely yours,

BEMIS.

Secretary Diven then read Question 11, viz.:

No. 11. Would electrically driven power heads be more desirable than steam heads for deep well work? Have any of the members of this Association had experience along these lines?

Mr. Heim: We have installed a pump driven by electricity, but we generate our own electric power. We paid the electrical company for three months current $473 before we had our own generator installed. Our fuel bill, for generating our own current was $551 for the last year. In our case running by electricity is the proper course to pursue.

Our well is located about 4,000 feet from the station. Of course you would not want to put up a steam plant near

the well. We generate the power at the station and carry it to the well as stated, with a small expense, by far cheaper than steam, and ready whenever we want to use the power, whether by day or by night, without keeping up steam. The same force of employes keep up the power at the pumping station for the motor at the well, and our all-around man looks after the motor. We use this motor on an average about four hours per day.

Mr. Rosamond: I asked that question for one of the Associate members of this association, and I have been unable to learn of the conditions at the point where they want to make a change, but I did learn this much: That they had an electric power plant in connection with a pumping station.

Secretary Diven: I do not know where the question came from. It came to me through Mr. Golden White, who asked me to present it.

Mr. Amsbary: In regard to that last question, with reference to the economy of electrically driven deep well power heads, compared with the standard type of steam deep well pumps, so much in use in this country, I would say that at Champaign, Ill., where I have charge, we once had our wells equipped with steam heads: these were set aside about five years ago, and power heads, each with two single acting plungers or valves, were installed. These power heads are driven with electric motors: the current is generated in our pump house, where we installed a Corless engine, belted the fly wheel to the generator; the engine is of the simple type, condensing.

Our wells are 160 feet deep and 8 inches in diameter; the working cylinder is 100 feet below the surface and is 5¾ inches inside diameter, and the water is delivered into surface reservoirs.

Before making the change in our system, we were burning about $4,000 worth of coal per year; after the change was made our coal bill was reduced to $1,800 per year, coal costing 95c. in the bin.

Secretary Diven read Question No. 12, viz.:

No. 12. Do large cast iron mains, even if properly laid,

settle to any extent in the course of time, when in city streets on which there is much heavy travel, including surface cars?

Reference being had to the possible danger in cases where mains cross each other, of the one above settling down upon and breaking or cracking the one underneath.

Secretary Diven: I should think that that question would be answered by saying that it would depend largely, if not entirely, upon the nature of the soil in which the pipe was laid.

Vice-President Tucker: I think there would be about the same danger in breaking the upper pipe as the lower one.

Secretary Diven read Question No. 13 as follows, viz.:

No. 13. Can any member suggest a practical method of insulating service lines to prevent freezing, where such lines lay in solid rock and have been carelessly installed at too shallow a depth?

A Member: Take them up and lay them deeper.

Mr. McNamee: The speaker is responsible for that question. He has been up against a pretty tough porposition in Wabash. Under the previous management there were a lot of service mains installed in streets that were underlaid with solid lime rock, and since have been paved with asphalt. So you see it is not quite as simple as it sounds to say "Take them up and put them deeper." They are so shallow that we have had difficulty with their freezing.

Mr. Gwinn: How did you protect them?

Mr. McNamee: That is what we want to find out.

Vice-President Tucker: You might take them up and wrap them with mineral wool.

Mr. Heim: It seems to me that by putting in 1½-inch pipe and shoving it right over those pipes, you can make an air space around the pipe which will save it.

Mr. Charles: I was going to suggest a possible relief, I cannot say a certain one. We have had pipe in Lexington crossing the bridge which had to be exposed. Our remedy there was to box it outside and then fill around it with

mineral wool. We have a valve at each end to provide a connection, and to cut out if anything does happen. So far nothing has happened. It has been there one winter.

Secretary Diven: I presume the idea of laying this in rock shallow is to avoid digging deeper where it must be done by blasting. I think possibly there are some very simple ways of protecting pipe in such places. I think if that pipe was dug up and a piece of plank or board laid over it, it might serve the purpose.

It is a curious fact that if you lay a board down upon the ground, the frost will go directly down on either side of it for a considerable distance before it goes in under it at all. A board of that kind laid directly on the pipe would protect it, and under ground that board would last a great many years. Or the pipe might be packed with tanbark, this covered with dirt and the air excluded would generate heat for a good many years, or fresh stable manure would answer the purpose.

I had an experience with hydrant branches freezing a year ago last winter, when the frost went to a greater depth than ever before. We had frost over six feet in depth and some of our hydrant branches were caught. I dug up the hydrants, went to a livery stable and got fresh horse manure and dumped it in the bottom of the ditch about the pipe, and it is an actual fact that at any time during the winter when testing those hydrants, the water was found to be warm. How long that condition would continue, I do not know, but I imagine for some years. What effect it had upon the pipes, I do not know. Somebody else has charge of that pipe now and he may find out.

Secretary Diven read Question 14 as follows, viz.:

No. 14. Has any member who used electricity for thawing mains or services observed any injury to such mains or services by reason of such use of electricity?

Mr. Heim: We have not had any service injured. We do not go beyond 50 volts for services. As long as we did not go beyond that, we had no trouble.

Mr. Gwinn: No electrolytic action has occurred?

Mr. Heim: No, sir, none at all.

Secretary Diven: In other words, with a direct current passing through the pipe there would be no jump of the current as used in thawing pipe, the two poles of the battery being attached to the two ends of the pipe and the current passed through.

Mr. Maury: Some of the current would doubtless leave the pipe; but as a rule that current is not on long enough for any one to observe any effect.

Secretary Diven read the following question.

In case of collapse of a kitchen boiler, caused by shutting off a main, is the water department responsible if notice had not previously been given?

Mr. Heim: I would state that we compel consumers to put in a check valve, so that in case the water is shut off the water remains in the boiler. If they do not comply with our rule, they are liable.

Secretary Diven: Do you put the check valve on supply pipe or outlet?

Mr. Heim: At the inlet. There would be no outlet as long as the swing check rests and the water remains in the boiler.

Secretary Diven: The heat generated would expand the water, and if a hot water faucet is open, force the water out. With the check valve on the inlet, and boiler full of water the expansion would force the water out of the boiler, if a hot water faucet was open.

Mr. Heim: As I understand this is a case where the water is shut off from the main accidentally, the check will prevent the water from running back into the main and thus emptying the boiler; if a hot water faucet should be open the water would escape that way, but that would be no fault of the water department.

A Member: If you compel them to put a check valve on their boiler supply pipe it will give them no relief in case there is a high fire in the range and steam is generated.

Secretary Diven: In the first place the check valve should be on the service near where it enters the house, to do the most good. On the other hand, as the member who has just spoken says, the check would work an injury

rather than a benefit, in case steam were generated in the boiler; for there would be no escape for it and the boiler would burst, which would be quite as bad as collapsing. It has always been my practice to warn people to open a hot water faucet, to permit the escape of any steam generated, in case the water was turned off when there was a hot fire in the range.

Mr. Heime: It is no concern of ours so long as the water is held in the boiler by the check valve.

Secretary Diven: That is surely a very comfortable view to take of it, from the superintendent's standpoint; but from an ethical standpoint it does not seem to me consistent. I fail to see why we are not just as responsible for the bursting of a house boiler as for its collapsing, and am inclined to think that the courts would take the same view.

This is a matter in which too much caution cannot be exercised; most householders are ignorant of the danger of maintaining a hot fire when the water is shut off, and it frequently happens that water has to be shut off without time to notify and warn them. I believe that it is our duty to educate them and instruct them how to act in such cases. These instructions should be sent to them at frequent intervals, they might be printed on the water bills; but it would be best to send them to the houses direct, as with the other method the tenant whose landlord paid the bill would not receive them. When water is shut off, and there is time to do so, cards with instructions on them should be left at every house, when notice of the shut-off is given. But as it so often happens that there is not time to give notice of a shut-off, instruction as what to do in such cases should be kept before the consumers.

As to the legal responsibility, that is a matter of locality and is governed by the local or State laws. Many waterworks charters and franchises provide for this, it being stipulated that the company is not responsible for accidents or in any other way for shutting off water for repairs or to make extensions.

Mr. Caulfield: At St. Paul we require a check and

safety valve wherever there is a boiler. We do it more for the protection of the water meter, from injury by hot water.

Mr. Tucker: This question does not take into consideration what may cause a boiler to drain out, but the query is, in the event that it does drain out, who is responsible?

A Member: Where proper specifications releasing the company from responsibility in event of breakdown of machinery, or anything else, are included in the application, and the application is signed by the property owner, the company is then protected from claims for damage due to such causes; in other words, the company is not responsible.

Mr. Gwinn: It seems to me that you could put a check valve on the supply pipe and that would prevent the water from draining out of the boiler. If the boiler is full of water when they shut off the mains, and there is a check valve on the supply pipe, I do not see how the water can get out of the boiler into the mains.

Secretary Diven: It might get out by the outlet pipe.

Mr. Gwinn: Certainly, if they draw it out; but they cannot do that very well, because the supply pipe comes out of the top of a boiler. I think it is necessary to have a check valve on the supply pipe to a hot water boiler, because in some houses they run a coil through the furnace for heating the water, and on very cold days when working the furnace very hard, steam is generated with sufficient pressure to force the water back through the supply pipe, and if there is a meter on, the hot water will cook the rubber piston or disc.

Sercetary Diven: I should think this question was intended to include any injury to the boiler by reason of shutting off the water without notice.

Mr. Tucker: I think that I recognize the handwriting of the one asking this question and know what called it forth. In our city some time ago I had occasion to shut off a main to make a connection, which I did, and up the street a short way a boiler, in this "shut-off" territory collapsed. As you all doubtless know, while the cold water pipes enter the boiler at the top the discharge is at the bottom with a small

air-hole in the pipe just inside the boiler, at the top, to prevent siphon; but, in this instance the boiler was an old-style copper one and, I presume, did not have this air-hole, and the water was siphoned out and the boiler collapsed.

The question is asked here "Who is responsible?" and not "how to prevent a collapse." I do not know whether that might not apply in some cases and not in others. It might be governed by statutory provisions, or something of that kind, which would apply in one state and not in another."

Secretary Diven read the following question:

Why should not fire protection charges be based on the value of property protected without reference to appliances used, rather than so much per hydrant, hose connection or sprinkler head? If based on value of property protected, what would be a reasonable rate per thousand dollars of property?

The motion that this question be referred to Insurance Committee was agreed to, and the question so referred.

Secretary Diven read the following question:

What would be an equitable rate for water by meter to domestic consumers and for manufacturing, pumping against 620 foot head, with coal at $1.05 per ton, and distributing through a territory twelve miles long by one mile wide, domestic use being 3,000,000 gallons per day, manufacturing use 6,000,000 gallons per day; investment in plant, say $2,500,000, and price on basis of 1,000 gallons?

I think the propounder of that question ought to be referred to Mr. Benzenberg's last year's report and let him figure it out. Here is another question:

Would not a bureau of statistics of the American Water Works Association (paid for out of the funds of the society) be a good thing; such bureau could collect data to be used by members; the data to be furnished by the members along the lines of well-defined, complete and carefully digested questions as to fire service, contracts, station economy and meter rates; the information to be carefully tabulated?

Mr. Heim: I move that they be referred to the secretary.

Secretary Diven: There is a good deal to that question. I think when I get home I will send these questions that have not been discussed out again, and see if I cannot get answers to them. I think this last question is worthy of very careful consideration.

Mr. Alvord: That question impresses me as being a very valuable one. I think there is a germ of a good thought which this Association might make valuable. The New England Association, as you all know, has a specified form for furnishing information to be included in their annual report; and it is of very great advantage and value, especially to those who are considering broader questions of waterworks economy and the financial standing of various plants under varying local conditions. It has occurred to me more than once, and it has again been brought to my mind by this question, that this Association ought to adopt a standard form of report that such information could be furnished upon such forms, and gradually adopt that form in their annual reports. Such a form would elicit very valuable data if made by the members annually to this Association and distributed among our own membership. It would afford data that would be exceedingly valuable in a great many ways. I would suggest that this question receive consideration in some manner.

Secretary Diven: I think the question might be improved by leaving out the matter of fire and contract meter rates. It simply refers to rates here, and I think that general statistics as to coal consumption and statistics of that kind might be well enough.

Mr. M. N. Baker: Perhaps some of the members might be interested to know that something like twenty years ago a committee of this Association did get up a form for the annual report, somewhat in line with that which has been used for a good many years by the New England Water Works Association. The form gotten up by the American Water Works Association, so far as I know, was never put into use. Some years ago the American Water Works Association approved tentatively a form for annual reports, which has been used for the last fifteen

or twenty years by the New England Water Works Association.

Secretary Diven: I think, however, that was after it was stated by Mr. Bemis that there were only three waterworks west of the State of New York that were using those forms. I think that Milwaukee was one. Do you remember, Mr. Heim, what the other two were? Was Cleveland one of them?

Mr. Heim: I do not remember, but we adopted that form.

Mr. Gwinn: Perhaps it would be a good plan for us to get up some statistics of that kind, not only meter rates, but domestic rates, say for an ordinary six-room house, following the plan which Mr. Baker adopted in his book, "Manual of American Water Works," and then include hydrant rental and payments for other public uses.

In order to get the matter before the house, I will move that it be taken up by the secretary along those lines.

Mr. Alvord: In order to make a beginning in that line, how expensive would it be, if, for instance, blanks were printed at the expense of the society, distributed and returned as requested before the next meeting, the information received could be put on file for record. That would seem to me a very simple thing to do; it would arouse the interest of the members, and would furnish us with a beginning of what would seem to be very valuable data.

Mr. Rosamond: I would second that motion; I would think it a very important matter.

Mr. Alvord: I move, Mr. President, that the secretary be authorized to print the blank form now adopted, and send to the members of this Association one or more copies of the same, asking them to make returns before the next ensuing annual meeting. I make that in the form of a motion.

Mr. Caulfield: I move to amend that the replies be printed in the next annual report. It will save the members of the Association from replying to a great many circulars on some special subject. If that data were all received and tabulated by the Association, the information would be

open to all and it would save the members from the trouble of replying to very many circulars that they receive during the year. If the expense of such tabulating should not exceed probably $100, I think we ought to have it done.

Mr. Baker: There is no need of going to the expense of printing forms used by the New England Water Works Association, because they can be obtained in any quantity any year from Mr. Chas. W. Sherman, Editor of the Journal of the New England Water Works Association. I might say further that there is no use of going to the expense of tabulating, because that is already done. Every one who makes use of the New England schedule and sends in the returns finds the results tabulated and published yearly in the Journal of the New England Water Works Association. It is just duplicating work that has already been done.

Mr. Maury: I think that is perfectly correct. I cannot see what is to be gained by sending out all of these circulars and trying to get this information. Is it to establish anything like uniform rates, or to get things in such shape that any city council that wants rates reduced can pick out the lowest rates in the list and try to make the local company furnish water at those rates regardless of conditions? As the rates of the company with which I am connected are unusually low, we should have nothing to fear from the publication of such a table or rates; but others may not be so situated. I think we know enough about the attitude of that committee to feel that it is firmly convinced of the folly of trying to judge one city's rates by another; and therefore these data, which can only be secured with great difficulty and at great expense, would not be worth their cost.

If it is a question of uniform waterworks forms, then we have already a form recommended by the New England Water Works Association and sanctioned by the practice of that Association. I believe we also have a committee on waterworks forms. But I cannot see very much good to be gained by the sending out of circular letters, the answers to which will be very incomplete, and some of them given grudgingly, as we can all testify, because we have all

tried it. Why should we put the society to any expense in this connection?

Secretary Diven: The committee on fixing a standard of water rates made their final report last year, and has been discharged, and their report is considered as conclusive on that subject. I had in mind in this matter not so much water rates as a great many details of information as to the cost of pumping, and other detail of operation.

Mr. Maury: If it is a question of form, Mr. Baker has answered that; if it is a question of vital statistics, at least two magazines have done that; they have possessed facilities for securing statistics the equal of which we can never hope to possess. I refer to "Engineering News" and "Fire and Water Engineering."

Mr. Alvord: While I appreciate Mr. Maury's remarks, yet at the same time there is a good deal of valuable information that should be available to the society from its own members. If we have a good general form it would be interesting oftentimes to refer to this form for general information, if it were filed in an accessable manner in the society's records.

As to the remarks made by Mr. Baker, I was not aware that the tabulation of New England Water Works statistics extended to many of the plants which are covered by the membership of this Association; and it was with the thought that it should be extended to members of this Association that I prepared the motion. It would seem to me not an expensive matter if we sent out those blanks and tried the experiment of learning how far we could go in the direction of tabulating some general information about our own plants among ourselves. If we can gather information at the same time from other plants, all well and good; but as a small beginning it seems to me that we can do something along that line from the plants represented in this association.

Secretary Diven: Mr. Maury's objection can be gotten around in this way, that this information can be collected for our private information and not published, but be on

record in the secretary's office so that any member can get it by writing for it.

Mr. Maury: That really was not the gist of my objection. Anything like a complete compilation of even the essential points of water data would fill a large book. Two excellent books of that sort I have already referred to. We could not hope to equal the compilation contained in those books and we can get those books by paying a few dollars for them. They give us the facts. Undoubtedly the people who got that information could get it where we should fail. Any attempt that might be made by us to get it might result in our receiving fifty replies, or a hundred replies, and when we got those hundred, or fifty, I do not think they would be worth the time and money. I do not think the society should be burdened, especially in its present state of finances, with the expense that would be necessary in order to get such very meager results.

Vice-President Tucker: It occurs to my mind that this would be going to useless expense, seeking for information that we would not use after we got it.

Mr. Caulfield: My idea was not so much with reference to water rates as with reference to a number of other questions that might be included; for instance, with reference to hydrant rentals, and whether owned by a municipality. For instance, some cities pay interest on a bonded debt and the waterworks have their full revenue in lieu of hydrant rental. Then there is the matter of rate for automatic sprinkling systems and for private fire service. There is quite a good deal of data outside of rates that might be obtained. The rates, as has been stated, were fully tabulated by "Fire and Water Engineering" and by Mr. Baker, of the "Engineering News," in his book. The rates are not as important to my mind as some of the other data that might be collected.

Mr. Maury: I think Mr. Caulfield is not correct in saying that these data have not been published by either "Fire and Water Engineering" or "Engineering News." They are not tabulated, but they do give some of the very things that Mr. Caulfield is anxious to get; namely, hydrant rentals, and some other financial details, number of taps, lengths

of mains, cost of plants, and a good many valuable statistics covering all the important features of a plant.

In the matter of special contracts covering fire protection, it seems to me utterly futile to compile tables of rates. We cannot regulate our conduct by what somebody else does in some other place any more than we can fix rates for closets or baths or anything else according to what is the rate in another city. I have been chairman of waterworks committees for the Illinois Society of Surveyors, and I remember that I wasted a whole lot of time in writing a great number of letters to different people in the State of Illinois to get all the official data I could in connection with the plants. After I had got all I could I found that "Fire and Water Engineering" and "Engineering News" had beat me as to every detail and had a better showing in their books than I had been able to make. I know I tried hard, and confined my efforts to only one State.

Amendment offered by Mr. Caulfield above was now put, a standing vote being taken, resulting in ayes nine, nays four, and was therefore declared carried.

Mr. Alvord: I might add that Mr. Maury's compilation was an exceedingly valuable one. I wish to bear testimony to it right here and now. I have used it a great many times myself, and I am under great obligations to Mr. Maury for his efforts in getting together those facts. In the question of pump economy alone we are all interested. There are no secrets about it. There is nothing that will injure anybody in knowing all that we can know about it. That one matter will warrant us in collecting this information if nothing more. I am sure there is a great objection to the publication of rates, and I appreciate Mr. Maury's suggestion along that line. I for one do not care so much about knowing the rates, but I would like to know something more about pump economy in the average plant as we find it in operation to-day.

Mr. Maury: I do not want it understood that I have any objection to having our rates known, but I do wish to emphasise the fact that the rate in one place is absolutely useless as a basis for anybody else to act upon.

Mr. Gwinn: The object of original motion was that the secretary be authorized and instructed to send out circulars for a tabulated list of information referring to the operation and management of waterworks plants, and to get the rates paid by private consumers and by the city for hydrants and other public uses. Also further information as, in the judgment of the secretary, would be valuable to the members of this Association.

A vote was taken on Mr. Caulfield's amendment to the effect that the information when obtained be printed in the next annual report; the amendment carried, but the motion as amended has not yet been put.

A vote was now taken on the original motion as amended and the same carried.

Secretary Diven read the concluding question in the question box, which, however, was not discussed, as follows: "Manufacturers bring into a territory domestic consumers, and bring up property values and population. Should they, therefore, be favored in rates, and to what extent?"

On motion, the convention adjourned *sine die*.

MEMBERS PRESENT AT THE TWENTY-FIFTH CONVENTION.

ACTIVE.

Adkins, Ben C., Water Commissioner, St. Louis, Mo.
Affleck, Jno. A., Pres. Water Board, Harrisburg, Pa.
Ahrens, John T., Supt. Water Works, Nashville, Tenn.
Alvord, John W., Consulting Engineer, Chicago, Ill.
Amsbary, F. C., Mgr. Water Works, Champaign, Ill.
Baker, M. N., Associate Editor, Engineering News, New York City.
Barker, W. H., Secy. Water Works Trustees, Sioux City, Iowa.
Bauman, C. V., Comr. Public Works, Newark, N. J.
Beardsley, Joe C., Civil Engineer, Cleveland, Ohio.
Berry, J. P., Supt. Water Co., Waterloo, Iowa.
Blauvelt, Albert, Nat. Fire Protection Assn., Chicago, Ill.
Boardman, A. E., Trustee Tampa Water Co., New York City.
Boeh, Wm. H., Chief Engr. Water Works, Cincinnati, Ohio.
Brown, C. Arthur, Consulting Engineer, Lorain, O.
Brown, Calvin S., Neptune Meter Co., Toledo, O.
Brown, D. A., Official Reporter, Cincinnati, O.
Bruen, G. E., National Fire Protection Assn., New York City.
Burns, T. W., Supt. Water Works, Fairburg, Ill.
Caird, James M., Chemist and Bacteriologist, Troy, N. Y.
Calhoun, H. L., Supt. and Secy. City Water Works, Fort Worth, Tex.
Calkins, Willis N., Chicago, Ill.
Campbell, C. H., Supt. Water Works, Charlotte, N. C.
Caulfield, John, Secy. Water Dept., St. Paul, Minn.
Charles, S. A., Civil Engineer, Lexington, Ky.
Chisham, J. M., Director Water Co., Atchison, Kan.
Clark, D. H., Supt. Water Works, Ironton, Ohio.
Clark, H. W., General Mgr. Water Works, Mattoon, Ill.
Cobb, Chas. H., Supt. Water Works, Kankakee, Ill.
Cole, Edward S., Hydraulic Engineer, New York City.
Conard, W. R., Inspector of Materials, Burlington, N. J.
Connor, F. J., Supt. Water Works, Faribault, Minn.
Cook, T. R., Supt. Water Works, Toledo, Ohio.
Crandall, William S., Municipal Journal, New York City.
Darch, F. J., Chairman Water Board, London, Canada.
Davey, T. W., Supt. Water Works, Middletown, N. Y.
Deffenbaugh, J. M., Water Commissioner, Lincoln, Neb.
Deutsch, W. M., New York City.
De Young, James, Supt. Public Works, Holland, Mich.
Dill, Howard A., Supt. Water Works, Richmond, Ind.
Diven, J. M., Supt. Water Works, Charleston, S. C.
Donahue, Jas. P., Secy. and Treas. Water Co., Davenport, Iowa.
Durlin, Willis R., Water Commissioner, Erie, Pa.
Eggers, August F., Pres. Water Board, Newark, N. J.
Ellis, R. N., Supt. Water Works, Jacksonville, Fla.
Ellwanger, John, Pres. Water Board, Dubuque, Iowa.
Ellwood, O., Secy. Water Board, London, Canada.
Ericson, John, City Engineer, Chicago, Ill.
Felix, Geo. H., General Mgr. Water Works, Reading, Pa.
Fellows, C. L., City Engineer, Toronto, Canada.
Ferguson, W. H., Supt. Water Works, Springfield, O.
Ford, Edwin H., Hartford City, Ind.
Frailey, E. F., Supt. Water Works, Lancaster, Pa.

Gailey, S. A., Supt. Water Works, Altoona, Pa.
Gallagher, John G., Supt. Water Works, Kingston, N. Y.
Glazier, W. L., Supt. Water Works, Newport, Ky.
Goodell, Jno. M., Editor Engineering Record, New York City.
Goodwin, Wm. G., Supt. Water Works, Kansas City, Mo.
Griswold, F. M., National Fire Protection Assn., New York City.
Hague, Chas. A., Consulting Engineer, New York City.
Heeger, E. G., Water Commissioner, Evansville, Ind.
Heim, John B., Supt. Water Works, Madison, Wis.
Hill, Wm. R., Civil Engineer, Brooklyn, N. Y.
Hollingsworth, Robt., Chief Engr. Water Dept., Camden, N. J.
Holmes, Alba L., Hydraulic Engineer, Grand Rapids, Mich.
Horner, C. M., Supt. Water Works, East St. Louis, Mo.
Hornung, Geo., Civil Engineer, Cincinnati, Ohio.
Keeler, H. E., Pres. Rogers Park Water Co., Chicago, Ill.
Kelley, John C., New York City.
Kelly, N. J., Supt. Western New York Water Co., Buffalo, N. Y.
Kennedy, Geo. G., Supt. Water Works, Harrisburg, Pa.
Laing, H. H., Supt. Water Works, Racine, Wis.
Leisen, Theo. A., Chief Engr. Water Dept., Wilmington, Del.
Lyon, Henry L., Deputy Water Comr., Buffalo, N. Y.
McAlpine, A. H., Columbus, Ohio.
McArthur, Arthur, Supt. Water Works, Dubuque, Iowa.
McConnell, J. H., Supervisor Water Works, Minneapolis, Minn.
McNamee, T. W., Supt. Water Works, Wabash, Ind.
MacDonald, Emmett, Supt. Water Works, Lincoln, Ill.
Maignen, P. A., Hydraulic Engineer, Philadelphia, Pa.
Manville, Fred, Local Mgr. Water Works, Newport News, Va.
Mason, W. P., Prof. Rensselaer Polytechnic Institute, Troy, N. Y.
Mather, Edmund, Water Commissioner, Harrisburg, Pa.
Maury, Dabney H., Consulting Engineer, Peoria, Ill.
Meyers, A. H., Supt. Water Works, Columbia, Pa.
Meyers, A. N., Water Registrar, Milwaukee, Wis.
Milne, Alex., Supt. Water Works, St. Catharines, Ontario.
Miller, Jos. Torrence, Penna. Water Co., Pittsburg, Pa.
Nourse, H. O., Supt. Bureau of Water, Chicago, Ill.
O'Shaughnessy, Jerry, Supt. Water Works, Columbus, Ohio.
Parkin, R. R., Supt. Water Works, Elgin, Ill.
Patton, W. A., Pres. and Mgr. Water Co., Catlettsburg, Ky.
Peene, Edward L., Supt. Water Works, Yonkers, N. Y.
Phillips, T. C., Hydraulic Engineer, New York City.
Poetsch, Chas. J., City Engineer, Milwaukee, Wis.
Prenter, Martin, Secy. and Gen. Mgr., Pittsburg, Pa.
Prentice, Allen T., Mechanical Engineer, Chicago, Ill.
Randolph, W. C. N., Supt. Water Works, Lynchburg, Va.
Rapp, W. M., Supt. Water Works, Atlanta, Ga.
Robinson, W. C., Rep. National Fire Protection Assn.
Rosamond, S. J., Supt. Water Works, Fort Smith, Ark.
Rowe, Chas. E., Supt. Dept. of Water, Dayton, Ohio.
Ruthrauff, Harry, Supt. Water Works, Decatur, Ill.
Ryder, Philip T., Treas. Water Board, Dubuque, Iowa.
Sheppard, Jas. H., Supt. Water Works, Monongahela City, Pa.
Shepperd, F. W., Fire and Water Engineering, New York City.
Sherrerd, M. R., Mgr. and Supt. Dept. of Water, Newark, N. J.
Simpson, Lawrence, Secy. Water Works, Memphis, Tenn.
Slocum, Chas. Egbert, Supt. Water Works, Belleville, Ill.

Smith, A. P., Hydraulic Engineer, Newark, N. J.
Sprenkle, Jno. F., General Mgr. Water Works, York, Pa.
Sterling, Joe C., Supt. Water Works, Monroe, Mich.
Strauss, H., Pres. Water Board, Ashland, Ohio.
Taylor, S. A., Civil Engineer, Pittsburg, Pa.
Thuman, Chas. J., Supt. Water Works, Evansville, Ind.
Tilden, J. A., Hersey Mfg. Co., Boston, Mass.
Todd, Wm., Supt. Water Works, Austin, Minn.
Travis, Isaac N., Supt. Water Works, Orange, N. J.
Tucker, A. A., Supt. Water Mains, Memphis, Tenn.
Van Duyne, J. Ralph, Resident Engineer, Newark, N. J.
Veach, Wm. Allen, Manager Water Works Co., Newark, N. J.
Verner, T. H., Supt. Water Works, McKeesport, Pa.
Watkins, Thomas, M. E., Johnstown, Pa.
Welling, Robt., Supt. Water Works, Covington, Ky.
Wiles, C. W., Secy. and Treas. Water Works, Delaware, Ohio.
Williams, H. L., Supt. Water Works, Ludington, Mich.
Wingfield, Nisbet, Consulting Engineer, Augusta, Ga.
Worrell, M. L., Secy. and Treas. Water Co., Selma, Ala.

ASSOCIATE.

Arnold, V. E., Pittsburg Meter Co., East Pittsburg, Pa.
Badenoch, Joseph, Ludlow Valve Mfg. Co., Chicago, Ill.
Bailey, Geo. E., Jr., National Meter Co., Boston, Mass.
Baldwin, Chas. H., National Meter Co., Boston, Mass.
Bancher, G. Y., National Meter Co., Cincinnati, Ohio.
Barnard, L. S., Hersey Mfg. Co., Buffalo, N. Y.
Bates, Fred S., Rensselaer Mfg. Co., Troy, N. Y.
Beers, W. D., Jas. B. Clow & Sons, Chicago, Ill.
Bennett, R. D., Central Foundry Co., New York City.
Bradley, F. J., National Meter Co., Chicago, Ill.
Buss, W. L., Chapman Valve Mfg. Co., Chicago, Ill.
Caldwell, Jas. H., Ludlow Valve Mfg. Co., Troy, N. Y.
Carr, Geo. E., Henry R. Worthington, Chicago, Ill.
Clifford, T. C. Pittsburg Meter Co., East Pittsburg, Pa.
Corbet, M. A., Safety Meter Lock Co., Columbus, Ohio.
Davis, J. H., Pittsburg Meter Co., East Pittsburg, Pa.
Dean, Mark, Central Foundry Co., New York City.
d'Auria, Luigi, Builders' Iron Foundry, Providence, R. I.
Doran, H. F., Neptune Meter Co., Bellevue, Pa.
Dwyer, Thomas E., Lead Lined Iron Pipe Co., Wakefield, Mass.
Finch, N. W., National Meter Co., Chicago, Ill.
Fischer, Geo. J., Modern Iron Works, Quincy, Ill.
Folger, Henry C., Thomson Meter Co., Brooklyn, N. Y.
Ford, Francis D., Ellis-Ford Pipe Cutter Co., Detroit, Mich.
Francis, C. S., National Meter Co., Chicago, Ill.
Glauber, Jas. H., Glauber Brass Mfg. Co., Cleveland, Ohio.
Hall, Frank E., Union Water Meter Co., Worcester, Mass.
Hamilton, Paul H., Hersey Mfg. Co., Youngstown, Pa.
Hanley, P. M., Hersey Mfg. Co., Kansas City, Mo.
Harrison, Samuel, H. R. Worthington, New York City.
Hawks, A. W., General Chemical Co., Chicago, Ill.
Hawks, B. C., General Chemical Co., Chicago, Ill.
Holmes, W. A., Pittsburg Meter Co., East Pittsburg, Pa.
Holley, E. B., Neptune Meter Co., Chicago, Ill.
Humphrey, E., U. S. Cast Iron Pipe & Foundry Co., Chicago, Ill.
Irving, Geo., National Meter Co., Boston, Mass.

Jones, A. E., Rensselaer Mfg. Co., Chicago, Ill.
Jones, Octavus, Rensselaer Mfg. Co., Chicago, Ill.
Ladd, E. G., Chicago Bridge & Iron Works, Chicago, Ill.
Leck, D. B., National Meter Co., New York City.
McCarthy, D. B., Neptune Meter Co., New York City.
McCormick, J. H., H. Mueller Mfg. Co., Cleveland, Ohio.
Merkle, E. J., Bourbon Copper & Brass Works, Cincinnati, Ohio.
Mull, E. F., Hersey Mfg. Co., Boston, Mass.
Mueller, F. B., H. Mueller Mfg. Co., Decatur, Ill.
Mueller, Henry, H. Mueller Mfg. Co., Decatur, Ill.
Naegle, T. J., Hays Mfg. Co., Erie, Pa.
Nelson, F. B., Pitometer Co., Columbus, O.
Oliver, W. P., National Meter Co., New York City.
Otis, Albert S., Union Water Meter Co., Worcester, Mass.
Pray, A. J., Pittsburg Meter Co., East Pittsburg, Pa.
Putnam, Capt. H. T., Thomson Meter Co., Detroit, Mich.
Relda, Howard C., Glauber Brass Mfg. Co., Cleveland, Ohio.
Resek, S., Farnan Brass Works, Cleveland, O.
Ross, William, Ross Valve Co., Troy, N. Y.
Romley, D. E., H. Mueller Mfg. Co., Indianapolis, Ind.
Sanders, B. H., Pleuger & Henger Mfg. Co., St. Louis, Mo.
Smith, Fred A., Hersey Mfg. Co., New York City.
Snow, E. J., Thomson Meter Co., New York City.
Stewart, Chas., Neptune Meter Co., New York City.
Todd, C. C., Universal Pipe, Chicago, Ill.
Weaver, A. T., American Steel Wire Co., Chicago, Ill.
Whitcomb, Fred N., A. P. Smith Mfg. Co., Newark, N. J.
Witherel, C. M., Neptune Meter Co., Rock Island, Ill.
Wood, Walter, R. D. Wood & Co., Philadelphia, Pa.
Wythe, Gordon, National Meter Co., Chicago, Ill.
Yeiser, L. B., the Sanitary Co., Cleveland, Ohio.

LADIES PRESENT AT THE TWENTY-FIFTH ANNUAL CONVENTION.

Mrs. Affleck, John A., Harrisburg, Pa.
Mrs. Amesbary, T. C., Champaign, Ill.
Mrs. Baldwin, Chas. H., Boston, Mass.
Mrs. Bauman, C. V., Newark, N. J.
Mrs. Bird, F. E., St. Paul, Minn.
Mrs. Bradley, F. J., Chicago, Ill.
Mrs. Bust, Frank, Toledo, Ohio.
Mrs. Caulfield, John, St. Paul, Minn.
Mrs. Cobb, C. H., Kankakee, Ill.
Mrs. Colton, Chas., Dayton, Ohio.
Miss Cook, Velma G., Toledo, Ohio.
Mrs. Corbet, M. A., Columbus, Ohio.
Mrs. Egan, N., Dayton, Ohio.
Mrs. Eggers, A. F., Newark, N. J.
Mrs. Felix, Geo. H., Reading, Pa.
Mrs. Finch, N. W., Chicago, Ill.
Mrs. Frailey, E. E., Lancaster, Pa.
Mrs. Frances, C. S., Chicago, Ill.
Mrs. Glauber, Jos. H., Cleveland, Ohio.
Mrs. Golden, J. B., Evansville, Ind.

Mrs. Goodell, J. M., New York City.
Miss Griffin, Alice, Lafayette, Ind.
Mrs. Hanna, L., Toledo, Ohio.
Mrs. Haslam, Minneapolis, Minn.
Miss Haslam, Minneapolis, Minn.
Mrs. Hinds, Jos. E., Harrisburg, Pa.
Mrs. Holmes, A. L., Grand Rapids, Mich.
Mrs. Joyce, John L., Columbus, Ohio.
Miss Joyce, Lucelle, Columbus, Ohio.
Mrs. Keeler, H. E., Chicago, Ill.
Miss Keeler, Georgie, Chicago, Ill.
Mrs. Kelley, John C., New York City.
Miss Kelley, Josephine, New York City.
Mrs. Kennedy, Geo. G., Harrisburg, Pa.
Mrs. Kelley, William, Toledo, Ohio.
Mrs. Leisen, Theo. A., Wilmington, Del.
Mrs. McAlpine, A. H., Columbus, Ohio.
Miss McClannahan, Mame, Decatur, Ill.
Mrs. McDonald, Mary A., Lincoln, Ill.
Miss Martin, A. G., Chicago, Ill.
Mrs. Memhard, A. A., Chicago, Ill.
Mrs. Mueller, H., Decatur, Ill.
Miss Mueller, Leonora, Decatur, Ill.
Mrs. Oliver, W., Brooklyn, N. Y.
Mrs. Patton, Emma A., Catlettsburg, Ky.
Mrs. Peene, Edwin L., Yonkers, N. Y.
Mrs. Pitou, Eugene, New York City.
Miss Pitou, Nora, New York City.
Mrs. Prenter, Martin, Pittsburg, Pa.
Mrs. Putnam, Detroit, Mich.
Mrs. Reig, Dr., Toledo, Ohio.
Miss Salmon, Florence V., Beloit, Wis.
Mrs. Simpson, Lawrence, Memphis, Tenn.
Mrs. Slocum, C. E., Belleville, Ill.
Mrs. Strattam, S. S., Jr., Richmond, Ind.
Mrs. Todd, C. C., Chicago, Ill.
Miss Todd, Jeanette, Chicago, Ill.
Mrs. Vopen, Louisville, Ky.
Mrs. Weil, Samuel, Cincinnati, Ohio.
Miss Wells, Mary Folger, Brooklyn, N. Y.
Mrs. Wingfield, A. B., Louisville, Ky.
Mrs. Wingfield, Augusta, Ga.
Mrs. Wright, Chicago, Ill.

GUESTS PRESENT AT THE TWENTY-FIFTH ANNUAL CONVENTION.

Adler, E. P., Davenport, Iowa.
Anderson, Alex. L., Davenport, Iowa.
Auill, A., Delaware, O.
Barr, Jas. S., Kenosha, Wis.
Bird, F. E., St. Paul, Minn.
Birner, P., Lincoln, Ill.
Bond, L. A., Indianapolis, Ind.
Bradley, H. C.
Bresinham, Wm., Columbus, O.
Brouse, Macy A., Kokomo, Ind.

Bust, Frank, Toledo, Ohio.
Caldwell, F. D., Evansville, Ind.
Canterbury, J. R., Minneapolis, Minn.
Clarke, E. E., Minneapolis, Minn.
Collins, H. W., Detroit, Mich.
Colton, Charles, Dayton, Ohio.
Davis, John R., Jacksonville, Ill.
Dersen, Geo., Columbus, Ohio.
Doherty, M. J., Chicago, Ill.
Doran, M., Jr., St. Paul, Minn.
Dramond, Jno. E., Mankato, Minn.
Egan, John E., Dayton, Ohio.
Edmonds, John, Lincoln, Ill.
Emerson, E., Davenport, Iowa.
Fessler, E., Morris, Ill.
Gailey, S. A., Jr., Altoona, Pa.
Gardner, J. W., Chicago, Ill.
Gearhardt, Fred P., Altoona, Pa.
Golden, J. B., Evansville, Ind.
Goodman, S. L., Springfield, Ill.
Haase, F., Milwaukee, Wis.
Hanna, L., Toledo, Ohio.
Harrison, J. F., Jackson, Mich.
Hassel, Otto, Chicago, Ill.
Hinds, Joseph E., Harrisburg, Pa.
Holmes, Chas. B., Minneapolis, Minn.
Judy, P. M., Delaware, Ohio.
Kelly, Wm., Toledo, Ohio.
Kleeman, Benton F., Chicago, Ill.
McLaskey, H. G., Minneapolis, Minn.
O'Brien, J. P.
Patterson, T., Morris, Ill.
Pitou, Eugene, New York City.
Raymond, Jas. H., Chicago, Ill.
Reig, Dr., Toledo, Ohio.
Riker, Andrew, Minneapolis, Minn.
Rosenthal, Silas, Lincoln, Ill.
Salmon, Edward, Beloit, Wis.
Satterlee, W. E., Minneapolis, Minn.
Saulpaugh, C. H., Mankato, Minn.
Schoon, Frank L., Minneapolis, Minn.
Schricker, R. L., Davenport, Iowa.
Scott, George N., Jacksonville, Ill.
Spitley, Chas., Lincoln, Ill.
Stoliberg, John, Toledo, Ohio.
Strattam, S. S., Jr., Richmond, Ind.
Taylor, Chas T., Mankato, Minn.
Telfer, John K., Morris, Ill.
Underwood, Jas., Roscoe, Pa.
Vopen, Mr., Louisville, Ky.
Weil, Samuel, Cincinnati, Ohio.
Wingfield, A. B., Louisville, Ky.

OBITUARY.

HENRY C. STILLWELL.

Born Providence, R. I., June 11, 1842.

Died St. Louis, Mo., August 13, 1904.

COL. A. M. MILLER, U. S. A.

Engineer in charge of waterworks extension and filter system, for Washington, D. C.

Born November 1, 1843.

Died September 14, 1904.

J. A. MARRION.

Civil and Mechanical Engineer, Montreal, Can.

Died December 2, 1904.

OBITUARY.

Death has, also, claimed since our last convention, others prominent in water-works circles and affairs, viz.:

HENRY GILBERT LUDLOW,

Founder of the Ludlow Valve Mfg. Co., of Troy, N. Y.

Born at Nassau, N. Y., March 28, 1823.

Died at Troy, N. Y., December 9, 1904.

JOHN P. K. OTIS,

Of the Union Water Meter Co., Worcester, Mass.

Always a faithful attendant at the conventions of the association, and a worker in its interests.

Born, Worcester, Mass., March 9, 1853.

Died, Worcester, Mass., December 31, 1904.

MRS. WILLIAM RYLE,

Wife of past-president William Ryle.

A constant attendant at the conventions and always taking a deep interest in the affairs of the association.

ENTERTAINMENT.

The Committee on Entertainment displayed the most praiseworthy energy and the best of management in catering to the comfort and amusement of the delegates.

On the evening of Monday, May 8, an informal reception was held in the hotel ball room. A dance followed and light refreshments were served. Mr. Denison, with a corps of volunteer assistants, took special care of the ladies.

On the afternoon of Tuesday, May 9, they were taken for a carriage drive to the many points of interest in the neighborhood of West Baden and French Lick. In the evening they attended the theatre, where excellent amateur talent from the Association furnished the guests with an evening's entertainment. The following program was provided:

PART I.

"AN EVENING WITH JAMES WHITCOMB RILEY."

Song—"There, Little Girl, Don't Cry," Riley....Mrs. Goodell

"An Appreciation of James Whitcomb Riley".Mr. W. P. Oliver

During this number Mr. Oliver recited the following selections from Mr. Riley's works:

"In the Days Gone by."
"When the Frost is on the Pumpkin."
"Long Afore He Knowed Who Santy Klaus Wuz."
"Out to Old Aunt Mary's."
"An Old Sweet Heart of Mine."
"Little Orphant Annie."
"A Serenade—to Nora."
"Wen De Folks is Gone."
"Knee-deep in June."

PART II.—MISCELLANEOUS.

Song ..... Miss Cook
Song ..... Mr. Barnard
Recitation ..... Mr. Charles
Song ..... Mrs. Goodell

Remarks ..... Mr. H. O. Nourse
Song ..... Mr. Barnard
A Number by ..... Mr. Charles

All the performers distinguished themselves and were heartily applauded. Mr. Oliver's talk on James Whitcomb Riley was of a very high order, and was greatly appreciated—in fact, all were excellent and appreciated. To many of those present it seemed a great surprise that the Association contained talent of such excellence.

On Wednesday, May 10th carriages were placed at the disposal of the ladies for drives as their fancy dictated. In the afternoon they played "Progressive" cards, for prizes. The evening was given up to illustrated papers, with lantern slide views. Many of the ladies attended this session.

On Thursday, May 11 no special provision was made for the morning's entertainment. In the afternoon, however, there was a warmly contested game of baseball, between nines composed of Associate Members, captained by Mr. H. J. Putnam, and Active Members, captained by Mr. B. C. Adkins. The game was umpired by Messrs. Jerry O'Shaughnessy and Chas. A. Hague, and it was generally remarked that, while it is possible that there are men in the Association who know less about baseball than these two gentlemen, it is highly improbable. The result was a victory for the Actives, the first occasion on record where they got the better of the supply men. Mr. Hague enforced order and obedience to his rulings with a musket, and the game was a very fair one. In the last innings Mr. Maury, when called out on strikes, on three wildly pitched balls, first looked a little surprised, then, hurt. Finally, he smiled and retired to the bench.

In the evening there was a banquet, for which the main dining room of the hotel was given over to the Association. It was served in fine style, and was followed by a ball, which acted as a stopper on any after dinner speeches.

On Friday evening a vaudeville, by professional talent, was given in the theatre, and a good program was rendered and enjoyed by all.

In addition to the above were provided golf, horseback riding, walks, and other amusements common to such resorts.

There were furnished spring water and "water-works" water—the latter so bad that many were driven to the springs; and, having gone there no change of mind was possible, of mind, maybe yes; of beverage, no.

On Saturday, after a short business session, the order of the day was—packing and "Good-Bye."

EXHIBITS.

Unusually good facilities were offered to our associate members to make exhibits at this convention, and many took advantage of them. Under the direction of Mr. Fred Mueller, chairman of the committee on exhibits, the arrangements were most complete. The large rotunda of the hotel was set apart for exhibits, ample and tastefully arranged decorated tables were provided, and all signs were of uniform size, making a very fine effect.

The exhibitors and exhibits were as follows:

SANITARY COMPANY, CLEVELAND, OHIO.
A full display of "Paragon" brass goods.

NEPTUNE METER CO., NEW YORK, N. Y.
Water Meters.

ROSS VALVE CO., TROY, N. Y.
Regulating Valves and Feed-water filter.

UNION WATER METER CO., WORCESTER, MASS.
Rotary and Disc Water-Meters.

SAFETY LOCK CO., COLUMBUS, OHIO.
Water-Meter and Stop-Cock Seals.

H. W. CLARK, MATTOON, ILL.
Large display of Clark Meter Boxes, showing boxes for all sizes of Water-Meters.

NATIONAL METER CO., NEW YORK, N. Y.
Large display of Water-Meters, including the new "Recording Meter," for mains, large services, fire lines, etc.

THE PITOMETER COMPANY, NEW YORK, N. Y.
Pitometer showing operation in detecting Leaks, Pump Slippage, etc.

CENTRAL FOUNDRY COMPANY, NEW YORK, N. Y.
Line of "Universal Water Pipe" set up and under pressure.

NATIONAL BRASS AND METAL CO., MINNEAPOLIS, MINN.
Aluminum model of Stop-Cock Box.

GLAUBER BRASS MFG. CO., CLEVELAND, OHIO.

Full line of Water-Works Brass Goods.

HERSEY METER CO., BOSTON, MASS.

Rotary, Disc and Torrent Water Meters and Meter-Boxes.

H. MUELLER MFG. CO., DECATUR, ILL.

Full line of Water Works Brass Goods, including, also, Tapping-Machine, shown in operation, Curb Boxes, Pipe-Jointer and Tools, and Lead Flange Connections.

HAYS MANUFACTURING CO., ERIE, PA.

Water Works Brass Goods and Stop Cock Boxes; the "American Water Works Beauty" was, also, displayed here.

THOMSON METER CO., BROOKLYN, N. Y.

Various sizes of Water-Meters, some shown in section, to give a view of the working parts.

H. R. WORTHINGTON, NEW YORK, N. Y.

Piston and Disc Water Meters, Oil and Beer Meters, straight-reading and extension Dials.

A. P. SMITH MFG. CO., NEWARK, N. J.

Water Works Brass Goods, Pipe Tools, including Tapping Machines for both large and small taps, Pipe Cutters, etc.

LEAD LINED IRON PIPE CO., WAKEFIELD MASS.

Samples of Lead and Tin Lined Pipe and Fittings.

ELLIS-FORD PIPE CUTTER CO., DETROIT, MICH.

Cast Iron Pipe Cutters and Flush Tank Meter.

PITTSBURG METER CO., EAST PITTSBURG, PA.

Keystone Water Meters—⅝-inch, to 2-inch and sectional models.

THOMAS WATKINS, JOHNSTOWN, PA.

Pipe Jointer, with section of pipe showing Jointer in place.

LUDLOW VALVE MFG. CO., TROY. N. Y.

Two views of Oil Line Switch House, fitted with Ludlow Valves and Appliances.

R. D. WOOD & CO., PHILADELPHIA, PA.

Cuts of "Mathews Fire Hydrants" and other views.

MODERN IRON WORKS, QUINCY, ILL.

"Peerless" Stop Cock Boxes, and other Water Works Appliances.

PAPERS PRESENTED

AT THE

TWENTY-FIFTH ANNUAL CONVENTION

OF THE

AMERICAN WATER WORKS ASSOCIATION

AND DISCUSSIONS ON THEM.

WHAT WOULD BE A FAIR BASIS FOR FIXING WATER RATES FOR FIRE AND DOMESTIC SERVICE?

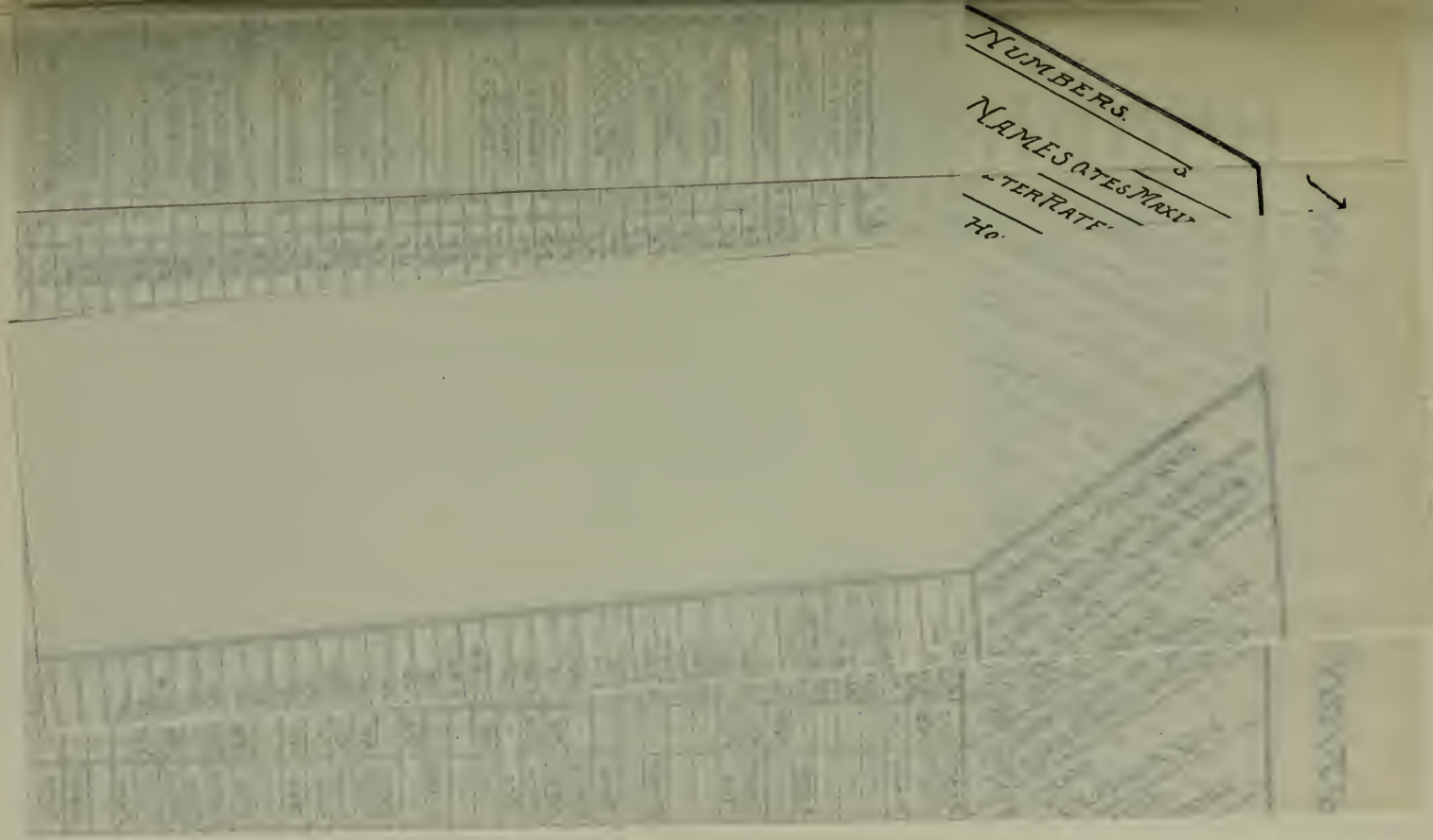
By S. J. Rosamond, Ft. Smith, Ark.

The title of this paper is in the form of a question, for the purpose of bringing out a discussion on this most important subject which the writer hopes will result in getting more information in our printed record than he is able to impart.

It has been truthfully said by some of our ablest members that rates must be fixed by local conditions, and it is hoped that the tabulations accompanying this paper, and other data added thereto by the members here present, may be of some aid to water-works officials and municipalities in renewing contracts.

During the past year the company which I represent and the city of Fort Smith, Arkansas, have been trying to reach an agreement on the terms of a renewal of our contract, and, in order to show by comparison what is required of other water-works and what compensation is received for service rendered, the writer sent out the following inquiry to two hundred cities.

Give name of your city? Give name of your company? What is your population? What is your pumping capacity? How many gallons of water pumped per day? What is the cost of your fuel per ton? How many fire hydrants in use? Give size of hydrants? What does the city pay per hydrant annually? What is your domestic pressure? Is the domestic service direct or from reservoirs? What is the elevation of your reservoirs above city? What is your fire pressure? Have you a standpipe? Give capacity of standpipe? What is the elevation of your standpipe above city? Do you pump direct at any time for fire pressure? Give pressure? What amount of free water is furnished your city annually? Give number of gallons? Have you a system of flush tanks? How many? How often are you required to flush them? What other free services are furnished city? What is the minimum meter rate to factories? What is your maximum meter rate? How many miles of mains have you? Give


NUMBERS.
NAMES OF STATES MAKI
TERRITORIES
No.

TABULATION OF WATER RATES. No. I.

Numbers	Names of City	States	Population	Pumping Capacity Per Day	Amount of Water Pumped Per Day	Number of Hydrants	Size	Price per Year	Domestic Pressure per Sq. Inch	Fire Pressure per Sq. Inch	Is Service Direct from Stand Pipe or Res.	Is Water Pumped Directly by Any Power	Capacity of Stand Pipes or Res.	Elevation of Stand Pipes above City	Amount of Fire Water to City Annually in Gallons	To Public Buildings	Number of Fires Last Year	Flushing from Fire Hydrants	Meter Rates Maximum	Meter Rates Minimum	Number Miles of Mains	Size of Mains	Underground Pipes from Tanks to Reservoir	Pumps to Reservoirs	Cost of Coal Per Ton	Elevation of Reservoir above City	How often are Tanks Cleaned	Amount for Flushing Hydrants	Cost Both Pumping Engines	Laundry Tax	Horse Tax	Bicycle Tax	Gas Tax	Electric Light Tax
1	Kenosha	Wis	14000	3000000	800000	172	4 6 8 10 12	70	110	Around Pipe	Yes	Gas 2000000 Electric 1000000	Pr.	100	Gas 2000000			Yes	Cyl. 50	Cyl. 25	32	Inches 16 12 8 6	Inches 16 12		$ 3.00	140	11 hours						28.00
2	Rockville	Conn	4500	1000000	2250000	2	4 6	30	100	80	-	No	250000	220	Not Known	All	100	-	25	7	00	6 4	12 4		1.00	143	None						26.00
3	Fort Dodge	Iowa	2500	500000	325000	8	6	Cyl.	85	185	Direct	Yes	None		"	"			85	10	85	16 - 4	16 - 12		2.00								
4			20000	3000000	2000000	53		5000	40	40	-	-	250000				12		50			16 - 4			Meters		1 Daily						20.00
5			25000	3000000		308		45	80	85	-	-	150000			-	70		30						Meters	110							
6	Fulmelia	NY	35000	4500000	5000000	600		38	36	110	-	-	None	118	-	-	6					20 - 4	16 - 12										29.00
7			7000	1500000	1500000	200		18	24	40	Stand Pipe	-	200000	188		Cyclone			50	10	78	30 - 8	30 - 12										Meter
8	Denison	Tex	12000	4000000	1800000	121		78	70	125	-	No	165000		-	Tornado	31	Yes	50	10	20	16 - 4	16		3.00	8.10							
9			18000	4000000	5500000	70	4 6 8	60	70	70	Direct	Yes	None					No	15	8	40	10 - 8	10		3.00	2.10	None						-
10	Danvers	Mass	8000	2000000	300000	240	6	36	60	80	Res	No	-						40	80	20	10 - 4	10 - 8		2.00								35.00
11	Oneida	NY	11300	3000000	760000	157		3333	72	75	-	-	350000	140	300000	None	42		40	80	20	10 - 4	10 - 8		2.00		1 in 2 hrs						31.00
12	Nebraska	Neb	11000	2000000	800000	81		37.50	65	90	-	-	70000		300000	Cyclone	16		50		14	12 - 4	12 - 8		2.00								28.00
13			19000	3000000	3000000	230		35	40	90	Direct	-	None		None	None	29		50	10	57	24 - 4	24 - 12	8.00	2.00								Meter
14	Roanoke	Va.	30000	4000000	3000000	124	6	30	65	80	-	-	-			Tornado				50	53	16 - 8	16	12.00									30.00
15			15000	4000000	2500000	138		60	40	100	Both	No	-	130	Not Known				85	50	23	12 - 4	16	8.50									62.00
16			10000	3000000	1800000	114	4 6 8	42	60	80	Direct	No	-		Not Known				35	17	14	10 - 4	16	5.10									26.00
17	Owensboro	Ky	15000	3000000	600000	163	6	45	60	90	Res	No	-	64	-	-	81		55	10	21	20 - 4	20	9.00	2.00	206							13.75
18			15000	3000000	1000000	177		52	26	90	Both	Yes	270000		None		16	Yes	25	15	20	16 - 4	16	1.85									21.00
19			16000	2000000	2000000	60		25	60	90	Res	-	None						40	16	16		14 - 10	6.50									32.00
20			17000	750000	300000	140		45	55	80	-	No							85	10	35	30 - 8	30										7.00
21			28000	Country		108		75	60	80	-	-							35	15	33	18 - 4	24	5.00									Meter
22	Butte	Mont	35000	7000000	3000000	428		65	40	40	Direct	-	-			Fire Stn		Yes	50	20	50	30 - 6	24 - 10	2.00									24.75
23			25000	2500000	6500000	208	8	60	80	80	-	Yes	-			City Bldg			19	05		18 - 4	18 - 12	5.75									31.00
24			17000	3000000	3000000	136		30	65	70	Both	-	150000	150		-					25	16 - 4	18										20.50
25	Vincennes	Ind	15000	3000000	1800000	220	6	40	35	80	Both Stand Pipe	No	350000		1000000	-	100		35	10	22	20 - 6	24	4.00			1 Year						31.00
26			11400	2000000	800000	101		56	75	110	Direct	Yes	None		None				30	10	31	16 - 4	16	8.00	300 Ft.								24.00
27			18000	4000000	2500000	228		32	72	100	Both	-	450000	210		Prairie	8		25	15	30	18 - 4	18	3.35									24.50
28			22000	4000000	1500000	235		37	30	110	Res	No	None		Not Known	Yes			40	40	30	18 - 6	16 - 12	3.25			210 Ft.						27.50
29			30000	8000000	8500000	370		40	32	70	-	-	750000	98	-	-			23	10	60	18 - 4	18	Meas.									31.00
30			18000	4000000	1000000	188		54	90	90	Res	Yes	None		-				30	10	25	20 - 4	16 - 12	3.00									24.00
31			30000	11000000	8500000	418		43	40	90	Direct	Yes	None		2500000		70		40	20	52	18 - 4	14 - 12	2.00			2 in 24						42.00
32	Marion	Ohio	16000	3000000	800000	312		33	45	90	Both	-	330000	188	2500000	-			25	10	20	18 - 4	18	3.00									33.00
33			17000	3000000	1800000	283		46	65	110	Direct	No	None		None	-			30	10	35	20 - 6	18 - 8	8.00									22.00
34			14000	3000000	1800000	147		50	40	90	-	Yes	-		-	-			20	10	22		18	2.00									Meter
35	Oak Park	Ills	26000	3000000	1250000	658		21	30	40	32	Both	-	78000	145	-	18		25	12	62	18 - 4	24 - 12	2.10			3 Years						25.50
36			15000	3000000	2500000	128		58	90	90	-	-	None		1500000	-			35	10	25	18 - 4	10 - 8 & 6	.35	170	1 Years							2.00
37	Champaign	Ills	18000	3000000	1000000	210		40	45	100	Direct	-	-				25		35	17	30			1.00									
38			25000	13000000	3000000	300		40	70	110	Both	-	170000	200		Chestnut	100		45		50	24 - 4	16 - 12	2.05									
39			30000	3000000	1000000	150		60	50	80	-	-	300000		23000000	City Bldg	55		20	60	27			1.00									28.00
40	Chillicothe	Mo	9500	1000000	700000	134		33	60	90	-	-	180000		-	-			50	20	13			1.00									
41	Lincoln	Ills	11000	4500000	6000000	113		42	50	110	-	-	150000	115	3400000	-			30		14	12 - 4	10 - 12	1.85									21.00
42	Osnabrook	Iowa	12000	3000000	2000000	118		34	35	70	-	-	200000		5000000	-			40	25	23	18 - 4	10 - 8	3.00			5 Daily						23.00
43			18000	4500000	3000000	189		50	50	115	-	-	200000	100	10000000	-		Yes	85	10	15	10 - 4	10 - 10	2.00									23.21
44	Richmond	Ind	20000	10000000	18000000	302		37	65	110	Direct	-	None		2000000	-	40		35	10	30	16 - 6	20	4.00									25.00
45	Sedalia	Mo	22000	4500000	15000000	185		40	50	110	Both	-	160000		200000	-	100	No	30	10	25	16 - 4	16	1.15	280								35.50
46	Kankakee	Ills	13000	3000000	1200000	152		43	35	100	-	-	270000	120	16000	-			35	15	20	18 - 4	18 - 12	2.75	120	1 in 24							28.50
47	Datonmoore	La	15000	2500000	700000			58	50	100	-	-	150000	150	Not Known	-			50	10	10	18 - 4	18	4.00	270								
48	Nashua	NH	25000	3250000	2000000	458		30	40	100	Both	-	-		-	-			30	08	80			3.00									18.00
49			12000	2000000	1750000	184		46	40	100	Direct	-	None								27	16 - 4	16	1.50	185								38.00
50	Bellville	Ills.	20000	3500000	800000	107		74	40	100	Both	-	Gravity 200000	100	2000000	-		-	30	17½	30	20 - 4	20	6.45	280								28.00
51			10000	3000000	650000	148		43	43	115	-	-	150000					-	30	10	14	18 - 4	18										Meter
52	Jackson	Miss	24000	5000000	3500000	170		45	60	90	-	-	350000	65	2000000			Yes	25	15	23	20 - 4	20	3.45									45.75
53	Akron	Ohio	35000	10000000	6000000	403		40	60	80	Both	-	None		1500000			-	33	18	70	24 - 4	24 - 20	8.00									25.30
54	Davenport	Iowa	42500	28000000	3500000	612		38	80	110	-	-	-		4000000			-	33	08	65	20 - 6		Pr.									
55			20000	5000000	4000000	177		40	80	100	Res	-	-	270	6875000			-	25	25	38	30 - 2	36 - 8	3.50									22.50
56			30000	12000000	8250000	328		40	50	100	-	-	-		Not Known		18	-	50	15	48	18 - 4	18	2.40			1 in 24						Meter
57			15000	6000000	3000000	183		40	55	110	Both	-	350000	215			26	-	30	10	29	18 - 4	18	Cont.			2 - 24						
58	Everett	Wash	21000	7000000	800000	130		43	60	100	Direct	-	None		3000000		43	-	10	08	31	20 - 6	20	2.50									
59	St Joseph	Mo	110000	21000000	15000000	649		40	60	120	-	-	600000	340				-				100	20 - 6	20 - 20	2.50									2.00
60	Brainard	Minn	10000	1500000	1000000	98		65	80	80	-	-	-		1500000			-			18	18 - 4	18	3.00									3.00
61	Raleigh	N C	15000	4000000	800000	180		40	50	80	Both	-	90000	115		Gravity Pressure		-	40	80	22	14 - 4	14 - 12										Meter
62			25000	4000000	8000000	200		35	65	100	Stand Pipe	-	325000	None		-	18	-	50	10	20	16 - 6	16	4.50	110								
63	Helena	Mont	12000	8000000		258		37	100	100	Res	Res			8000000		85	-	40	00	56	18 - 4	18	2.40	132								35.00
64	Pine Bluff	Ark	16000	3000000	1000000	283		40	30	65	Both	Yes	100000	150		-	84	-	40	10	14	14 - 8	14 - 6	4.00	150								25.00
65	Iron		10000	4000000	850000	172		50	30	90	"	"	300000	200	7000000	-		No	30	00	17	16 - 8	16	8.50	220								4.00
66	Tampa	Fla	23000	7000000	2000000	327		35	60	61	80	"	-	None	150		None	38	23	12½	24	18 - 3	18	2.50									18.00
67			25000	8000000	2600000	167		25	50	90	"	"	150000	184		-	35			15	67		18										23.50
68	Salina	Kan	10000	3500000	1800000	130		35	50	100	"	"	150000	140	825000	Gravity Pressure	40	-	45	15	15	14 - 4	10 - 8	1.00			3 Daily						21.45
69			30000	7000000	3300000	243		35	50	100	-	"	410000	80		-	37	-	25	10	30	10 - 4	10 - 10	1.75			2 in 24						-
70	Lexington	Ky	30000	8000000	1800000	353		30	50	100	Direct	"	None		1800000	"	85	Yes	25	10	30	18 - 4	18 - 10	2.25			1 - 24						13.00
	Total		1653	435000000	131000000	15019		3011	4735	6417									1870	770	2274			3.058									1300.30
	Minimum		8000	2000000	450000			30	26	40									10	05				.85									15.75
	Maximum		110000	85000000	21000000			75	100	115									80	25				5.25									61.00
	Average							44	57	87									31	11				2.59									20.18

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1905

size of mains? What is the size of your main supply pipe to city, or from your pumping plant to the city? Please give here any other information that in your judgment would be of value to us. Please attach your annual rates. Information furnished by whom?

Replies were had from one hundred and two cities, seventy of which were found fairly complete. See Table No. 1. This information was of such great value to us that the writer undertook to get the consent of the conrtibutors to use same in a paper before this association and, with that end in view, sent out the following.

On November 19th the writer sent out an inquiry for the purpose of gathering data to be used in settling our differences with the city of Fort Smith. Since tabulating and using this information, the tabulation has proven of such value that the writer wishes to make same a part of the records of the American Water Works Association, so that any water company may have access to same in future. The writer has found these tabulations of great value in convincing our city officials as to what should be required of us and what compensation a company should be entitled to for certain services. I now ask you, as a contributor, to permit the writer to use this tabulation at our May meeting. You will kindly indicate your wishes on the return postal card. Also state how many gallons of free water per year is allowed your city.

Replies were had from forty, giving consent, two objecting, and twenty-eight not heard from. Therefore these are referred to by numbers only. Reference to this table shows a wide range as to requirements as to fire pressure, 125 lbs. being the maximum and 40 lbs. the minimum. Average, 90 lbs., while in the majority of cases 90 lbs. to 100 lbs. is what is required. This, with liberal sized mains, will supply six to eight good streams (see Freeman's table). which is considered ample for small cities.

Hydrant rentals seem to be the main point of difference between water companies and municipalities. This the writer thinks is explained by the table. Note the wide range and without any apparent cause; maximum $79.25,

minimum $21.50, while the average is $44 per annum. The writer knows of one city that is paying $20,000 per annum for all fire hydrants that the city may order the water company to set for the next twenty years, and also free water for municipal uses, for sewer flushing, and for public buildings.

This is the most unreasonable contract the writer has found in the investigation, and it is just such as this, coming to the knowledge of politicians, that is making trouble for water companies.

"It is impossible for a board of aldermen or a legislative body to determine a rate that will be fair to both the public and the corporation. This can only be done by men who have had long familiarity with the details of the business."

"In 1892 Mr. Allen Ripley Foote wrote a discussion of the economic principles involved as an introduction to The Law of Incorporate Companies Operating Under Municipal Franchises. In the course of this discussion it is said: When a service is public, the price should be fixed by an authority superior to both buyer and seller; a power that can adjudicate all causes of action between them. There is one limitation upon the power of regulation. The limitation is that the price fixed shall be reasonable compensation for the service performed. A compensation that will not cover the necessary expenses and a reasonable profit is not reasonable. Any enforced compensation that is not sufficient for these purposes is an act of robbery. The determination of a reasonable price is a judicial, not a legislative act. That it may be judicial, it must be passed upon by those who have no interest in the case, and who have access to all the facts necessary to enable them to arrive at a correct conclusion." I should add that the one selected to pass on this question should also "have had long familiarity with the details of the business."

The seventy cities tabulated show the following average:

Miles of mains per 1,000 population..	1-23
Hydrants per 1,000 population.....	10-1
Hydrants per mile of main.....	8
Average pressure	90 lbs.
Average annual rental per hydrant..	$44.00

A system built to render fire service together with domestic service will cost 33⅓ to 47 per cent. more to construct than a system constructed for domestic service alone. "Folwell" estimates the average cost of a system of water works built in the Southwest as $21,580 per mile of mains? Then if 33⅓ to 47 per cent. of the cost be extra for fire service, would it not be fair for hydrant rentals to yield fair interest on 33⅓ to 47 per cent. of the cost of the plant plus 33⅓ per cent. of cost of betterments and replacements? Estimates based on 33⅓ per cent. of the extra cost would yield a rental of $500 to $600 per mile, and with ten hydrants per mile would be $50 to $60 for hydrants per annum each. Added to this should be a fair portion of any extra cost of maintaining the service on account of any extraordinary pressure and cost of maintaining a purification system, not common in most plants.

The next item to be considered is the "free water provisions," for municipal use, for public buildings, fountains, and flushing sewers, found in many of the early contracts before the damaging nature of such provision could be known.

In many cases the amount of water so used and wasted if reckoned at a minimum rate has been far in excess of the amount paid by the city for hydrant rentals. By the disposition of city councils to add annually to this service, it has been and always will be a ruinous factor in the operation of water companies. The maintenance and price for fire service (that is, hydrant rentals), and the service for other municipal uses should be considered and paid for separately.

More water is wasted under such a contract than is used. As an illustration attention is asked to a very able paper on this subject in the 1903 Proceedings, page 543, by Mr. Howard A. Dill, of Richmond, Indiana.

A test of free services in that city made by Mr. Dill showed a leakage on the system of 81,532,245 gallons annually. Reckoned at 10 cents per thousand gallons this would be $8,153. My own test at Fort Smith at one time showed double the amount, and at a time when we were receiving from the city less than $6,000 per year from

hydrant rentals. The table shows that Mr. Dill has reduced the consumption to less than one-third the above amount.

A study of the tables will also show a wide range in domestic water rates, some being so low that it is hard to understand how a company with such low rates can live. For comparison, the writer has applied the published rates of the different companies to a six-room house with sink, wash-stand, bath-tub, closet, laundry-tray, horse, buggy and cow, also 50 feet lawn, and we find the minimum $15.75, the maximum $82.80; average, $28.18.

I now wish to call your attention to table No. 2 which gives the domestic rates of another group of forty cities, which were also taken from the published rates of the cities named. This table deals with the rates in detail and shows as wide a range as table No. 1, but note the average $29.13, which is very near that of table No. 1. Fort Smith, Arkansas, for the same service being $22, a rate which has proved to be far too low.

Attention is called to the minimum rate on water closets, $1.50 per annum. Can water be pumped to these wasteful fixtures at the rate above named? The average flush, not including leaks, is not less than ten per day, and at five gallons per flush this would be 18,250 gallons, and this reckoned at the average minimum meter rate of 31 cents for this class of service, would be $6.82.

Again quoting Allen Ripley Foote: "When a service is rendered by a private corporation for the public purposes of the municipality, the price paid by the municipality limits its cost to tax payers. When the same service is rendered by the municipality for its own account, through the ownership and operation of the industry, the price to tax payers is the entire net cost of the service." Thus, if the hydrant rentals be made to yield interest on 33⅓ per cent. of the investment plus 33⅓ per cent. of betterments and replacements then the private consumer must pay a rate that will yield sufficient revenue to give a water company fair returns on the total investment.

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TABULATION OF WATER RATES, No. 2.

	Name of City	Name of State	Residence Rate — for 6 Rooms: Bf/house	Bath with Stationary Basin & Water Closet	Sprinkling (not front)	Horse with Carriage & Waiting	Cow	Laundry Tubs	Wash Bowl	Total House Rate	Barber Shops: Barbers	Barber Shop (1 Barber)	Barber Shop Each additional Chair	Bath Tub Public	Banks	Brick Houses	Butchers' Stalls	Drug Stores	Offices, Each	Restaurants	Families 4 Rooms	Families Each other Room	4 Room Houses: Plastering Annual	Stone work	Slicking Barn	Corner Lot Extra Sprinkling	Store 25 ft Front	Each 10 ft	Stores: Shade Each Side Horse	Urinal Private	Urinal Public	Water Closet Private	Water Closet Public — Stores	Warehouses
1	Everett	Ind	12 00	6 00	4 00	2 77	6 00	4 00	No Chge	No Chge	34 77			15 00	4 00	15 00			15					25	05			4			4 00	10 00	9 00		
2	Brainerd	Minn	9 00	5 00	5 00	5 00	1 00	1 00	" "	" "	28 00	9 00		7 00	3 00	10 00			10	20 00	9 00			30	10		12 00							
3	Davenport	Iowa	6 00	3 00	4 50	3 00	3 00	2 00	" "	" "	24 00													10							9 00	2 70		5 40
4	St. Cloud	Minn	7 00	3 00	4 00	4 50	4 00	2 00	" "	2 00	26 50	8 00		6 00	3 00	12 00	8 00		10					40	07						10 00	1 00	2 00	2 00	8 00	8 00	3 00
5	Iron Mountain	Mich	6 00	4 00	3 00	5 00	1 00	1 00	" "	2 00	22 00			5 00	1 00				15					10												
6	Biddeford	Me	10 00	5 00	6 00	5 00	8 00	2 00	" "	No Chge	36 00					15 00	10 00													3 00	6 00				
7	Little Rock	Ark	6 00	5 00	5 00	5 00	3 00	1 00	3 00	" "	28 00			7 50	3 00				10			25 00	4 00	1 00	50	04					5 00	10 00	10 00		
8	Yebraska City	Neb	8 00	6 00	6 00	5 00	4 00	2 50	No Chge	3 00	34 50	10 00		8 00	4 00	9 00			10					25	10			2	00	8 00			6 00	12 00	10 00	
9	Cortland	NY	6 00	3 00	4 00	4 00	3 00	1 00	4 00	2 00	28 00	12 00		8 00	2 00	10 00			10		15 00	8 00	25 00	4 00	1 00	40	10			2	00	9 00			8 00	4 00	6 00	5 00
10	Massillon	Ohio	6 00	2 75	2 00	5 50	2 50	1 00	4 00	1 00	24 75	15 00		5 00	3 00	5 00	9 00		08		15 00	3 00	4 00	1 00	25		3 00	2 00	7	75	2 50			2 25	5 00	6 50	3 00
11	Atchison	Kans	6 00	3 00	5 00	5 00	5 00	1 00	No Chge	No Chge	25 00	10 00	10 00	3 00	15 00				10		15 00	15 00	4 00	1 00	50	05			7			2 00	10 00	10 00	5 00	
12	Selma	Ala	6 50	3 00	3 00	5 00	5 00	1 50	2 50	2 50	29 00	25 00	6 00	2 00	12 00	8 00			10		12 00	5 00	10	5 00	1 50	100	10			2	00	12 00		1 50	3 00	5 00	5 00	
13	Kankakee	Ills	6 50	4 50	2 50	5 00	3 00	2 00	No Chge	2 00	25 50	7 00	5 00	2 50	10 00	10 00			08		10 00		5 00	75	15	05			10	00	8 00			2 00	8 00	8 00	5 00
14	Ithaca	NY	8 00	5 00	5 00	6 50	6 00	2 00	5 00	2 00	39 50	10 00	8 00	2 00	10 00				10		20 00	12 00	25 00	8 00		40	04			2	00	10 00		4 00	2 00	4 00	8 00	5 00
15	Vincennes	Ind	6 00	5 00	5 00	6 00	5 00	2 50	4 00	3 00	36 50	10 00	4 00	3 00	10 00	10 00		6 00	10		15 00	8 00	37 50	4 00	1 00	50	05	2 50	2 50	10	00		1 50	5 00	10 00	10 00	5 00
16	Raleigh	NC	7 00	4 00	6 00	5 00	6 00	1 60	2 50	2 00	38 10	10 00	5 00	3 00	12 00	10 00			10		15 00	10 00	5 00	1 25	40	07				10	00	5 50	1 60	4 00	10 00	10 00	10 00
17	New Albany	Ind	4 75	2 85	1 90	5 70	2 85	95	3 80	1 90	24 70		3 80	1 90		5 70			10		14 25	5 70			29	09								4 00	4 50	4 50	4 50
18	Grum Bay Wis	Wis	6 00	4 00	3 00	6 00	4 00	1 50	3 50	2 00	30 00	8 00	6 00	2 00	10 00	8 00			08				4 00	1 00												
19	Topeka	Kans	6 00	5 00	3 00	5 00	7 00	1 00	No Chge	No Chge	27 00	10 00	5 00	3 00	15 00				10		20 00	10 00	25 00	4 00	1 00		15			2	50	10 00			2 00	10 00	6 00	5 00
20	Pine Bluff	Ark	6 00	3 00	5 00	7 50	8 50	3 00	" "	" "	33 00	10 00	10 00	10 00	3 00	15 00			10		15 00	10 00	25 00	4 00	1 00	50	05					15 00		1 60	10 00	10 00	10 00	10 00
21	Menominee	Mich	7 00	3 00	3 00	5 00	8 00	2 00	1 00	2 00	23 00			4 00	2 00	6 00	9 00		10		12 00	5 00	20 00	5 00	1 00	50	06			2	50	10 00		1 60	2 00	3 00	4 00	
22	Danville	Ills	5 50	2 50	2 50	3 50	2 50	1 50		2 00	20 00	10 00		4 00	2 00	8 00	7 00		08			4 00	15 00	5 00	50	25	06							1 00	5 00	3 00	6 50	
23	Oskaloosa	Iowa	6 00	3 00	3 00	3 33	3 00	1 00	No Chge	1 00	20 33	20 00		5 00	3 00	12 00	10 00		10	15 00	20 00	5 00	20 00	6 00	1 00	20	05	3 00	3 33	8	00	2 00			3 00	5 00	5 00	
24	Knoxville	Tenn	8 00	5 00	5 00	8 00	5 00	2 00	" "	No Chge	33 00	8 00	5 00	2 00	10 00	8 00			10	12 00	15 00	5 00	20 00	6 00	1 00	35	04			6	00				4 00	8 00	8 00	
25	Marion	Ohio	12 00	6 00	6 00	6 05	5 00	2 00	1 60	" "	37 65	10 00	6 00	1 00	8 00	11 00			12	14 00	18 00	6 00	20 00	12 00		50	05							2 00	3 00	5 00	10 00	6 00
26	Richmond	Ind	6 00	5 00	3 00	5 00	4 25	1 00	50	" "	24 75		3 00	3 00	5 00				08		12 00	5 00		4 50	60	25	04		2 50								
27	Joplin	Mo	5 40	1 80	1 80	5 40	2 70	1 35	No Chge	" "	18 45	9 00		4 50	2 70	13 50	5 40		09	14 40	10 80	5 40		3 60	90	27	05	2 70	2 70	9	00	2 70	1 35	1 80	5 40	4 50	
28	Carthage	Mo	8 00	2 00	2 00	5 00	3 00	1 00	" "	" "	21 00	15 00		3 00	1 50	5 00	5 00			10 00	10 00	5 00		6 00	1 00	25		3 00	3 75	8	00	3 00	1 50	8 00	6 00	5 00	5 00
29	Henderson	Ky	5 00	3 00	10 00	6 00	3 00	1 00	" "	" "	28 00	12 50		5 00	2 00	10 00			06			4 00	15 00	4 00		33	03	2 00	1	00			1 00	5 00	5 00	5 00	
30	Peru	Ind	5 50	2 00	2 00	4 00	2 00	2 00	" "	50	18 00			5 00	2 00	5 00	4 00			5 00		4 00		5 00	50		4 00		8	00			2 00	3 00	6 00	4 00	2 00
31	Hot Spring	Ark	9 00	7 00	6 00	6 00	7 00	3 00	" "	No Chge	38 00	20 00	12 00	4 00	20 00	12 00			10		20 00	12 00	25 00	6 00	1 50	1 00	10	12	00	5	50	10	00	2 00	6 00	20 00	16 00	7 00
32	Birmingham	Ala	11 00	4 00	5 00	8 00	5 00	3 00	" "	" "	36 00	2 50	12 00	3 00	30 00	12 00			05		20 00	6 00	50 00	8 00	1 00	50	06	6	00	1	75	14	00	3 00	10 00	20 00	16 00	
33	Hannibal	Mo	7 00	5 00	5 00	5 50	4 00	1 50	" "	2 00	30 00			5 00	4 00	12 00	10 00		10	10 00	20 00	6 00	20 00	5 00	1 00	50	10	6	00			10	00	2 00	6 00	10 00		6 00
34	Fort Worth	Texas	8 00	6 00	5 00	10 00	2 00	2 00	" "	8 00	41 00	20 00	8 00	3 00	14 00	6 00			08		12 00	6 00	30 00	7 50	2 50	100	04	6	00			10	00	2 00	6 00	8 00		
35	Texarkana	Ark	10 00	5 00	5 00	5 00	8 00	3 00	" "	No Chge	39 00	2 50	7 50	2 50	20 00	10 00			08	10 00	15 00	15 00	30 00	7 50	2 50	100	10					10	00	3 00	8 00			
36	Kansas City	Mo	8 00	5 00	4 50	6 00	5 00	2 00	" "	" "	30 50	15 00	7 00	3 25	12 00	10 00			10	12 00	25 00	5 00	25 00	6 00	1 00	50	03		12	00	12	00						
37	Burlington	Iowa	7 00	5 00	4 00	6 00	5 00	1 00	" "	" "	28 00		5 00	3 00	15 00	10 00			05		25 00	4 00		5 00	1 00	25	05	4	00			1	00	4 00	8 00	10 00	6 00	
38	Memphis	Tenn	8 00	5 00	5 00	10 00	5 00	2 00	" "	" "	35 00	25 00	7 50	3 00	10 00	8 00			10		15 00	6 00	25 00	6 00	1 00	50						2	00	5 00	10 00	15 00		
39	Baton Rouge	La	6 00	5 00	1 50	5 00	3 50	1 50	" "	" "	25 50	24 00	6 00	2 50	10 00	10 00			05	20 00		10 00	50 00	8 00	1 00	15						3	50	3 00	10 00	10 00		
40	Owensboro	Ky	6 50	5 50	4 00	5 00	2 50	1 00	2 00	2 00	27 50	20 00	4 00	2 50	8 00	20 00			10	20 00	5 00	9 00	40 00	7 50	1 50	75	03					2	00	4 00	4 00	8 00		
	Totals		270 65	171 40	166 30	222 25	167 30	68 15	37 40	40 90	1163 35	413 50	232 80	105 95	446 50	264 10	39 00	168 40	411 05	218 60	552 50	174 90	2925	14 34	2 12	54 20	8	968	268	25	19	40	45	15	133 05	30	85	241	05	27	35
	Maximum		12 00	7 00	10 00	10 00	8 50	4 00	5 00	8 00	41 00	25 00	12 00	7 50	30 00	20 00	15	20	25 00	15 00	50 00	12 00	25	1 00	15	12	00	14	00	15	00	5	50	3 00	10 00	20 00	15 00	10 00
	Minimum		5 00	1 80	1 50	2 77	1 00	75	No Chge	No Chge	18 00	7 00	3 00	1 00	5 00	5 00	03	5 00	10 00	3 00	10 00	3 60	50	1 00	03	2 00	1	40	6	00	1	00	1	00	2 00	3 00	4 00	2 00
	Average		7 26	4 29	4 16	5 55	4 18	1 75	0 93	1 02	29 13	14 26	6 13	2 78	11 57	9 36	09	12 05	13 77	6 86	22 60	5 28	1 08	40	06	4 52	4	72	9	58	2	77	1	88	3 80	8 62	7 80	5 44
	Fort Smith		8 00	2 00	2 00	5 00	3 00	2 00	No Chge	No Chge	22 00	Metre	3 00	3 00	10 00	8 00	05	5 00	10 00	4 00	15 00	6 00	1 00	30	05	4 00	1	50	7	00	2	00	2	00	2 00	5 00	5 00	5 00

METHODS OF SELLING WATER; FLAT RATES; WANTON WASTES.

Is there a water-works man who has "had long experience in the details of the business" who will say that he has discovered a method of assessing what is known as flat rates; that is, fair to the consumer and the water company?

We never miss the water till the stream gets dry. It is not like human nature to prize highly that which costs us nothing, but the taking.

The writer has seen persons at hotels on the American plan where the price is so much per day for rooms and meals, come to the table and order the whole bill-of-fare, eat one-third and cause the waste of two-thirds. At a hotel on the European plan where rooms are let for a price per day and everything ordered at table is paid for at a fixed price for each article, the same person would order carefully, eat all they ordered, waste nothing. In both cases the patron eats about the same. In both cases the landlord must pay for all he sends to the table and must figure the cost of running his hotel in proportion. In the American hotel the careful patron must help pay for the waste made by the patron who orders more for waste than for his stomach. In both cases the general public must pay for the whole. So in supplying water with flat rates. If it costs the patron no more to leave the water running than to shut it off after using, a great many people, their servants and children, will leave the faucet open with water running to waste. What of it? Do we not pay for water? says the patron and is there not plenty of water? Oh, yes, but the water company must maintain a costly plant, and it must pay the cost of pumping and distributing every gallon of water taken from the lake or river, and the general public must pay the cost for the whole amount sent through its pipe.

The careful patron using flat rates helps pay for the waste of water wherever it occurs. Whether the city or a corporation owns the water plant, the full cost of buying, owning, and operating the property of pumping, cleansing, and distributing, must be paid for by the general public. No fair reason can be found why the careful water taker should help pay for the waste of the careless taker; therefore,

every careful user of water should have THE METER.

Some water companies have not the right to set meters to prevent waste. For the good of the general public all water companies should be given this right; and for the protection of careful patrons, for the welfare of the city, and for their own safety, should set this "Silent Watchman" to record the amount of water, whether carefully used by one or wasted and used by the other takers. There would be as much justice in supplying milk and groceries per family as there is in supplying water per family.

Attention is called to the difference in the consumption in the metered and unmetered cities as shown by the tabulations. Lexington, Kentucky, a metered city having a population of 50,000 and consuming only 1,500,000 gallons of water daily, while Sedalia, Missouri, an unmetered city, with a population of only 22,000, is consuming 1,500,000 gallons daily, and my own city, Fort Smith, Arkansas, which is about the same size as Sedalia, is using 2,500,000 gallons daily.

The foregoing is a most convincing argument that the only fair way to both the consumer and the water company is to sell water by meter measure.

In conclusion, I wish to give due credit to Mr. Charles W. Fenn, C. E., of Portland, Maine, who tabulated the data gathered by the writer.

Mr. Rosamond: After I returned home from the St. Louis Convention last year I began asking questions of waterworks men. I have not stopped doing so yet, and it is for that reason that the paper was full of questions. I hope I will get the fullest discussion, because I believe the subject is one that is of most interest to waterworks men right now on account of the fact that a good many old contracts are expiring and coming up for renewal. Since I have been at West Baden and have discussed this matter with several members of this Association, the opinion was expressed by some that the paper does not apply so much to cities that own their own plants, or to municipal plants, as to plants owned by private companies. I believe, however, that it does, because of the barrier that it throws around property that the city safeguards in its fire protection. In many cities that own their plants nothing is taxed against

the large real estate owner proportionately, but the small consumer who earns his daily bread pays the most of the expense of the water plant. For that reason I think that these facts apply more to cities that own their own plants than to privately owned waterworks.

DISCUSSION.

Mr. Boardman: Mr. President, in opening the discussion I want to call attention to one item which is mentioned as probably a proper charge for hydrant rentals: that is, on page 49 of the advance publication, where Mr. Rosamond says: "Added to this should be a fair portion of any extra cost of maintaining the service on account of any extraordinary pressure, and cost of maintaining a purification system, not common in most plants."

I cannot see how the cost of purification of water, which is not necessary in fire service for fire protection, should be estimated as a proper charge for the fire service of a city as hydrant rental. I agree with the writer perfectly that any extra cost of maintaining the service on account of the extraordinary pressure should be a proper charge. Most of the domestic pressure that is required in a city does not exceed thirty to fifty pounds, and that includes lawn sprinklers, etc.; but the general requirements of cities are that a much greater pressure should be maintained on the mains to be used instantly, before any appliances can be called upon to increase the pressure—to be used instantly by the fire department in the case of silent alarms and things of that kind, of which the pumping station can have no notification, or which neighboring plants or factories themselves may use.

Now, that extra pressure which has to be maintained requires larger pumps, larger boilers; and since if the constant pressure is necessarily maintained at a greater pressure than is required for domestic service, it means a constant extra cost for coal consumption and all the incidental expense of the waterworks. These are proper charges to be added to what would properly be charged for the domestic rate alone, and which the city should pay for in its fire protection; but I do not think that the cost of purification of water, which is not necessary in fire service, should be added. The amount of water actually used for fires is not of sufficient magnitude, taking the whole year through, to warrant a charge for purification of just that por-

tion which is used for fires.

I heartily agree with Mr. Rosamond in the necessity that is gradually being recognized, of metering services very generally; and having been on the "fire protection committee," my attention has been more directed to the benefit which a metered system exercises upon the maintenance of the general pressure for fire purposes throughout the system. Besides, it has the effect of retarding the necessity for large additions to your system to meet the extra requirements of fire protection; I heartily commend his remark to all who have to go before their cities in regard to contracts or for advising the introduction of meters.

Mr. Wm. R. Hill: In establishing a rental for fire hydrants, municipal officers are often misguided by the assumption that only the rent of the hydrant itself and the quantity of water that would probably be used, would be considered. Thus disregarding the fact that a large portion of the cost of installing and operating this plant was incurred for the sole purpose of making and keeping it efficient for fire protection, as has been so ably shown by Mr. Rosamond. And while it is possible that certain hydrants may not be used for a long period of time, still it is a fact that they will be furnishing a most efficient service in guarding at all times valuable property against most disastrous destruction by fire.

A most forcible example of the financial benefit derived from a properly installed system of fire hydrants is shown by the following: In the year 1897 the owners of property in Syracuse, N. Y., were paying an aggregate of about $600,000 per annum for fire insurance; but at once, because of the excellent protection against fire afforded by this improved water system with 2,168 hydrants, an average reduction of 25 per cent. was made in rates charged for fire insurance, resulting in a saving of about $150,000 per annum, which was equivalent to about $69 per hydrant.

Secy. Diven: In looking over Mr. Rosamond's tables I noticed one very unfavorable condition. He gives an average of eight hydrants per mile in seventy cities, which would put those hydrants 666 feet apart. That is entirely too far apart. At one time in making a contract with the city of Elmira for hydrant rental or fire protection instead of charging so much per hydrant, we took about the amount that they were paying

on the per hydrant basis at the time, added a little to it for additions during a five-year contract period, and gave them a lump sum for as many hydrants as they wanted; the hydrants to be furnished by the city and set by the company, and when set to become the property of the company. Our hydrants averaged 700 feet apart at that time. To-day they average less than 250 feet apart. It costs us no more to maintain our supply of water to those hydrants than it would to a smaller number, and they get a very much more efficient fire service.

Mr. Rosamond: That was one point that I wanted to bring out. The fire department in our city has upon occasions laid 1,250 feet of hose from the fire plug and expected service. We had a fire on the 29th of last month where there was but one hydrant within striking distance of the fire, and they would have accomplished more from that one hydrant than from the other two that they attached to, 700 or 800 feet away. The two streams that they got from the farther hydrants only weakened the force of the stream from the hydrant within striking distance. You will find a great many cities in which the average distance between hydrants is more than 650 feet. Ours average more than that. We have 65 miles of streets and 126 hydrants.

President Sherrerd: I cannot quite agree with one of the previous speakers in saying that no part of the cost of a purification system should be charged against fire protection; because it must certainly be true if the city expects to always have pure water in its mains, that the purification plant must be built larger or more costly in anticipation of maintaining fire protection, so that a greater rate of flow of pure water may be maintained in case of fire when the draft is increased beyond the normal consumption. Since storing filtered water will require the clear water basin to be covered, this would increase the cost of filter installation even when an old reservoir is available.

Therefore it would be, certainly, quite proper to consider as a factor in making up costs of the maintenance of fire service, which cost would certainly be more in cases where a filter plant is installed than in the case of a water supply that is not filtered. One other way to get around it would seem to be a dual system, wherein you have one line of pipes exclusively for fire protection and factory purposes, and another for potable

water. Certainly any such arrangement of a plant would be vastly more expensive than to increase the size of your filters.

Mr. Boardman: I still have to maintain my original position. It is no more necessary to increase the size of filters above your maximum daily consumption for fire purposes than it is to increase your mains. The extra amount of water to be drawn off in case of fire is provided for in the reservoir capacity, either in position to be used or available by your engines. That, I admit, *is* a proper charge for extra cost of furnishing filtered water for fire use, but not the cost of the filters themselves. It is seldom that filter systems are built with a view of giving filtered water during a fire entirely through the filters. They are either provided with by-passes, in case the reservoir should give out, or a reserve is supplied. It is the cost of that extra reservoir which I think is applicable to the extra charge in the rate for hydrants.

Secy. Diven: Do I understand the gentleman to say that filter plants are provided with by-passes by which unfiltered water is at times pumped into the mains? In my own experience I do not know of any such a case. It seems to me that in that event a city would be in a worse condition than if it had no filtered water. If whenever a fire comes polluted water is pumped into the mains, the water supply will never be safe; it will take days and probably weeks to get all of the polluted water out, and it would seem to me to be a very undesirable practice.

Mr. Boardman: Fortunately, I do know of several cases where the suction lines of the pumps extend into the rivers supplying the water which ordinarily is filtered. There are very few cases where they have had to be opened, but they do exist as a safeguard; and I think if the city authorities were given the decision of the matter they would prefer to fill the mains with undesirable water, which could be eliminated usually in a few hours, rather than to suffer the effects of a disastrous conflagration.

Of course it is not a desirable thing to do, but there are cases of that kind, and I do not know that I should say that they are not warranted; but I would advocate, of course, a large reservoir of filtered water ready for the pumps, and I do advocate that. At the same time I do not advocate relying

entirely upon any one appliance in case of a conflagration when others are at hand.

Mr. Patton: The question at issue is, whether or not the cost of filtration should be considered a part of the expense of maintenance of fire hydrants. Now in four-fifths of the cities of the United States they do not have dual plants. In fact, there are very few such. Therefore, if the city demands a filter, that filter should be considered a part of the investment in the construction of that plant, and the operation of the filter plant is a part of the maintenance or annual cost of that plant and is a part of the general expense; it is just as essential that that proportion of the expense, or that added expense, should be charged up to fire hydrants as to be charged to individuals.

Mr. Rosamond: I expected that, and a great many other points, to be raised. It is a small matter when you consider the amount of water required per capita for fire service. One authority gives it as one-tenth of a gallon. I think it is fair to place it at from three to five gallons per capita. I think that the extra cost of handling the water should be added to the fire hydrant charge.

I expected that some gentleman would bring up the question of rates per thousand gallons. I said nothing about it in the paper, because as I stated in one place there, I hold that those things should be determined by local conditions. But I bring out the point clearly that the domestic rate, whether it be metered or flat, should take care of itself in proportion to the cost of maintaining and operating the system.

Mr. Charles: I think that after filter plants are once established it is almost impossible to use anything but filtered water, and that the device of a by-pass is a very dangerous and unnecessary one. You should first of all have your clear water basin of sufficient capacity to meet an ordinary fire, or three or four of them, in addition to the domestic consumption. Then again, if you use a mechanical filter, you should have reserve filters by which you can add to the amount on hand and keep it going by simply throwing on additional filters.

Mr. Patton: What is of far more importance than considering the cost of the filtration plant is the added cost of maintenance of hydrants and the cost of water that is wasted by municipalities for which there is no consideration whatever; free

water in drives, free water for city buildings, free water for flushing sewers and for public grounds, free water for pools, these are the factors that add to the cost of a plant; and if you want to get at the cost of delivering water you ought to consider the quantity of free water that is given which produces no income. That is the most important feature that there is to be considered in this connection. If you want to know what a city ought to pay for a hydrant or for any other service, you ought first to know how much free water is to be carried along with the contract which they maintain for their hydrants. When you arrive at that conclusion then you can find out something about what the water company should get for the rental of a fire hydrant.

Mr. Boardman: That is just what such papers as we have had read before us show the necessity for eliminating. There should not be lumped into hydrant rental or cost of fire service any free water. Water should be paid for by the municipality, whether furnished by municipal plant or by a private corporation, for all uses (Applause), and the cost of that water, whether it is used for flushing sewers or sprinkling streets, if it is to be filtered water. One of the things which causes the cost of hydrants to appear greater when furnished by private companies than when furnished by municipalities is the fact that the amount of free water furnished is not recognized by city councils or city governments; and I think that the discussion of this paper is very useful to show the inequity of charging free water to the hydrant service, which service does not require a great deal of water, but does require a high pressure. They confound with that the large quantities of free water used by municipalities and not paid for or accounted for at all. It is a wrong principle to lump anything. You will get left every time. The department fools itself and the public, and the companies get cheated. Let all the water that is used be paid for according to the purposes for which it is used. (Applause.)

Mr. Rosamond: A test was made at Racine, Wisconsin, at one time of 111 flush tanks, and it was found that they were running 1,436,429 gallons per day, which at the usual minimum rate of ten cents per thousand gallons should have returned that company $40,529.65. I doubt if they were getting one-quarter

of that as hydrant rentals at that time. If that was not crippling a plant, I do not know what you would call crippling.

Mr. Leisen, Wilmington, Del.: In regard to the domestic rate mentioned by the former speaker ($22), it would seem to be rather high. In Wilmington we have a municipal plant, and consequently are governed by different circumstances, and naturally view this question from a different standpoint, but for a house of the size mentioned, our charges would be from ten to fourteen dollars per annum. If it were on a meter, the charge would probably not exceed the minimum rate of ten dollars, and yet on a basis of charges similar to this, we are enabled to turn over an annual surplus anywhere from $25,000 to $75,000. In addition all water for manufacturing and fire purposes is furnished free, and this includes municipal buildings, school houses, parks, sprinkling and all fire hydrants, and fire-sprinkler service to all manufacturing plants desiring it.

We charge a certain amount for fire hydrants (forty dollars each, I believe) in making up our accounts, in order to arrive at an equitable valuation of the amount of water delivered, but no actual charge is made for such service—and as stated before, under this schedule of charges we have a very material surplus each year,—a surplus that in recent years has been more than sufficient to liquidate the entire indebtedness of the Water Department.

President Sherrerd: Is there any appropriation from the City for the maintenance of the Water Department?

Mr. Leisen: None whatever. Furthermore, the water is pumped to an elevation of 140 feet for the low service, 240 feet for the high service, and about 320 feet for the extreme high service, with coal costing $3.50 per ton. In view of these facts it appears rather surprising that the rate of $22 mentioned here is spoken of as being too low for the service which we find profitable at half that amount.

Mr. Glazier: I represent the Water Department of Newport, Kentucky, as its Superintendent, which has been in a struggle with the balance of the city government. None of the other departments seemed to recognize any rights of the Water Department. We of course are anxious to make a creditable showing to the people, and to maintain and operate the

Department in an economical way. My predecessor, Mr. Hornung, took up the question of water waste in connection with the sewers, and he found after some experiments and considerable investigation and measurement of water, that there was being consumed about 780,000 gallons a day in sixty flush tanks. I was City Engineer at the time, and had some connection with him in looking after that matter. He originated a device which I carried out, of placing a disk which would admit only a certain amount of water from the pipes supplying the sewer tanks, properly regulating same. By this means we have gotten down the consumption from 780,000 gallons a day to about 60,000 gallons a day. This was done in the face of much opposition from other departments of the city, the Health Department claiming that the health of the city demanded a continual stream of water running through the sewers, whether flushing or not. The principle of flushing was entirely forgotten, or not understood by them.

The sewers are thoroughly and completely flushed at present, possibly far better than they were before attention was paid to the matter by the Water Department. I might state that the sewer system was comparatively a new one, and that this waste did not continue for any great length of time after Mr. Hornung took the matter up. If that water had been sold to private consumers the revenue would have been $117 a day. The cost now would amount to about $9 a day. The cost of pumping was somewhat under three cents, so even at that there was an absolute waste of about $25 a day of the city's money, but as it was not coming out of the departments that those other gentlemen represented, they didn't seem to care anything about it. The Water Department there has had a hard and continual fight. Municipal managers, I believe have as hard a time as the management of private plants, to get along with the rest of the city departments. We have more trouble with waste of water by public officials in Newport than with any of the private consumers. Some employees of the fire department seems to feel that they are entitled to waste all the water they choose. There is a sort of fascination about holding a large hose and letting the water run for an indefinite time. We have had especial trouble with the schools, and

have now taken the matter up with them and are refusing to put in a service for a new building which is going up until they comply with the regulation of the department and place a meter. We charge them nothing for the water, but simply want a check placed on the wasteful consumption of water. I came up here to find out from the members of the Association what the practice is in reference to supplying schools with water. Our commissioners asked me to find out as much as I could concerning the practice of the different cities relative to charging schools, and what the practice was in receiving credit for the amount of water furnished to these other departments.

Mr. Darch, London, Canada: This paper to me is a very interesting one, and while I am thoroughly in sympathy with municipalities owning ther own waterworks, I think it is of vast importance to municipalities owning their waterworks that correct charges be made by water departments against other municipal bodies. I take the ground that every tub should stand on its own bottom, and that where the city is being protected, that that protection should be paid for by the property owners. It is a well-known fact from those who have looked into the matter and from statistics that we can readily get at, that a large number of consumers of water are tenants in the first place, and small property holders. Now these tenants and small property holders contribute to the maintenance of a municipal plant; if that municipal plant is maintained by these water consumers and if no charge is made for fire protection to the municipality, then the municipality and the large property holders are benefited and are deriving that protection from the small consumers. In the city that I come from, a small city of 45,000 inhabitants, we have had to fight along the same line to a certain extent. Of course we have not come into real conflict with the municipal board, for we do make a charge for hydrant rental, and we also make a charge to schools, which pay the ordinary rentals such as ordinary consumers pay; and I think it is only just and right that they should do so and that the large number of small consumers should not be asked to pay for the protection of property interests of the city.

Mr. Burns: I have a friend who runs a small municipal

plant. He put a meter on a school house as an experiment, and discovered that the school house was using more water than the largest other consumer, who used 11,000 gallons per 24 hours. When their attention was called to the fact and that they were a separate taxing body, raising a separate tax, and really had no right to free water, they had their plumbing repaired and so conserved the use of water, that they are now only using about one-third the water they did before. I think that if the other gentlemen would take up the matter in a similar way they would be able to settle it without a quarrel.

Mr. Glazier: We have taken it up and it has not done much good so far. We put a meter on a four-room school house and found that they were using about seventeen thousand gallons a day. We have cut the waste down considerably now, and they are using but about 3,000 gallons a day. In one parochial school, with plumbing conditions about similar to another public school, where they obeyed orders to put in meters, conditions were almost precisely the same and the number of pupils was almost identical. They had the same appliances as the public school, yet the public school was using twenty-one times the amount of water per day that the parochial school was.

Mr. Henry L. Lyon (by letter): I made no reply at the convention to Mr. Rosamond's paper, "What Would be a Fair Basis for Fixing Water Rates for Fire and Domestic Service," because I thought it was unfair to compare a city of four hundred thousand inhabitants, having an unlimited supply to draw from, and pumping an average of 130,000,000 gallons per day, with a city of twenty-two thousand inhabitants, having such abominable muddy water, and pumping 2,500,000 gallons per day, but Mr. Rosamond personally requested me to reply by letter, and I will do so. I will first answer the questions that he has propounded to other cities.

City of Buffalo.

Bureau of Water, owned by City.

400,000.

212,000,000 Gallons per day.

Least amount pumped last year, 115,130,380 gallons. Great-

est amount 202,552,910 gallons. Daily average, 127,741,660 gallons.

Run of mine coal, $2.08 per ton.

4,720 Fire Hydrants.

6-inch Stand Pipes.

$15.00.

50 lbs. at Pumps on low service. 75 lbs. at Pumps on high service.

Direct. Our Reservoir is only used as an overflow, and in case of accident at the pumps.

Surface of water in Reservoir is 113 feet above level of water at Inlet Pier, but not high enough to supply some parts of the City.

We do not pretend to furnish pressure for fire, the fire steamers take suction from the hydrants. We also have about one and one-half miles of special fire line pipe, that is not connected with the water bureau system, but the fire tugs supply this line direct from Buffalo River, with a pressure of from 250 to 300 lbs. to the square inch. This is only through a part of the business section, and needs no steamer in addition.

We have no stand pipe, but the reservoir acts as a stand pipe, the pressure at the pumps being kept at 50 lbs., which will just balance the reservoir when filled.

The reservoir will hold 116,213,827 gallons.

Surface of water in reservoir, 113 feet above level of water at Inlet Pier.

We do not pump direct for fire pressure, except as explained above, on fire lines.

Low service 50 lbs. High service 75 lbs. Average through the city, 35 to 40 lbs.

All city departments pay regular water rates. We furnish no free water, except to State Hospital and Normal School, which was given the State as an inducement to erect these buildings here. There is also some water used by the Street Department for flushing streets, for which we do not receive pay.

The free water above amounts to about ten million gallons per month.

We do not have flush tanks.

Our meter rates are six cents per thousand gallons for the first 22,500 gallons each month, and two cents per thousand gallons for all above that.

Six cents per thousand gallons.

505 Miles.

4 inches to 48 inches.

24 inches, 36 inches and 48 inches.

It is hardly fair to compare our rates with those of a private company. Our Charter provides that we must be self-sustaining, but we do not try to make a profit. Our greatest trial is to divide the actual expenses as fairly as possible amongst the tax payers.

We provide for a fire line to manufacturing properties. These lines can not be tapped for any other purpose, the regular supply for service must be through a separate connection with the main. We seal all valves on the fire line, and charge $10.00 per year for the protection we furnish, and the expense of looking after the seals.

A flat rate for any service seems to be very absurd, but we have such an unlimited supply at our doors (the whole of Lake Erie) that citizens can not understand why they should be saving, and when we talk of the cost of pumping, it rolls off of them "Like water off a duck's back."

Our charge for meters is just about the actual cost of running the Bureau, and paying interest on our bonded indebtedness, with one-twentieth of the principal on bonds, which we pay each year, and generally is much less than the flat rate, but, when I tell any one that, if they pay more, they are only paying the actual cost and they should be willing to pay that, if they wish to be fair, it makes no impression on them.

Our ordinances are strong enough to permit metering everything, I having authority to order any place metered. But meters cost money, and the Common Council will not appropriate enough money for any extensive metering.

THE COMMERCIAL PUMPING ENGINE.

By Charles A. Hague, New York.

The growth of steam pumping engines for public water supply, has been slow, but nevertheless an interesting subject for the past fifty years. Its progress along the lines of adaptation and economical operation might be likened to a reverse Mariotte curve, the very symbol by which its steam performance has been so long judged. That is to say, beginning with the famous old Cornish engine which was so ruthlessly bundled out of the conditions of deep mine pumping under which it was developed, into the much more arduous task of forcing water through long lines of pipes; and following along through the vicissitudes of the problem, we find that the improvement was slow at first, and difficult though certain. Then as we look back along the road traversed, from the view point of the triple expansion machine produced to-day at less cost than its clumsy and wasteful predecessors, we see that the advancement at first represents the slight and gradual upward track of the reverse expansion diagram, until finally in later years the onward rush has carried the line of improvement more and more rapidly upward until the latest types stand at the top of a steep incline, with the possibilities of superheated steam and quadruple expansion looming still a little higher on the nearly vertical line of the present curve.

The "commercial" pumping engine has almost completely taken the place of the "special" pumping engine by the sheer force of repetition, until what a few years ago was only available through special talent and occasional opportunity, is now equaled and sometimes excelled by the regular output of several establishments enjoying enough of a business to keep a staff at work upon the water works pumping engine as a sort of commercial product.

In buying and installing a modern pumping engine, there seems to be a certain procedure which has come to be adopted during the gradual development of the business, and although shorter and bolder courses may at times be followed, upon the whole it will no doubt be found that natural evolution in the matter is a pretty safe guide to follow. It has seemed at times

as though the mere statement of the requirements to be met was all sufficient for the attraction of competition, and that the would-be buyer could be furnished with all the necessary information and details relating to what he was to get for his money, by the competitors themselves. This seems beautifully simple but there are certain attributes of human nature which completely defeat most of such efforts; each bidder wants the work, and as the object and aim of competition is to get the most and best for the money, the result is that the party with the lowest bid tries to convince the buyer that his machine is upon equal footing with the others and he has the lowest figures; while a higher or even the highest bidder tries to convince the buyer that he has very much the best proposition although at a higher figure, or the highest figure. The buyer's best course may be upon a middle ground somewhere between the highest and lowest; but he does not know if unfamiliar with the minutia of the subject, and when he sees the figures varying a hundred per cent. from the lowest to highest for what he supposes ought to mean the same thing, he is entirely at sea and begins looking about him for some sort of help out of his dilemma.

The wide open call for proposals for a pumping engine will result in this state of affairs sometimes, because certain vital details are not specified in the call for bids, and different bidders will offer machinery to be run at all sorts of speeds, the main object seeming to be to make the lowest price; and, although the lowest price accompanied by proper conditions, adequate dimensions, etc., ought to be the one chosen, it behooves the buyer to be certain that he is safe in his selection. Of course this brings up the question of professional or expert advice in making the proper selection, and the logic of this is that it will be better to have competent specifications prepared in advance than to endeavor to select a proper proposal from the grab bag collection resulting from what might be called "the open door."

The matter of specifications would seem at first glance to be very simple, and perhaps it is, to those builders who understand, and have the courage to offer what they really know ought to be furnished; but the ever present grind known by the name of competition coupled with the strongly grounded

idea that a contract should go to the lowest bidder, will assert itself and interfere with the fairly rational treatment of the subject. Besides this, there is a tendency amounting to a determination at times, to stipulate that the builder of pumping engines must provide all sub-foundations, foundations proper, do excavating, cut into and replace masonry, floors, walls, and whatever may be changed in the course of the installation of the machinery; thereby inflicting upon the maker of machinery a lot of work entirely and completely outside of his legitimate business and occupation. But the writer holds, and is encouraged in this belief by experience, that the best course for the buyer to pursue with reference to his own interest is to exempt the engine builder from all work and responsibility outside of the machinery itself even to the painting of it, leaving to him only that which he is prepared to handle, and leave his mind free from the haunting shadow of matters foreign to his business, and which he can not meet without a certain element of uncertainty as to cost, and the reflection of which most surely comes back to the buyer in the shape of increased price by reason of percentages added by the machinery maker to cover possible contingencies of which he can not accurately inform himself beforehand.

In this age and day, when shop practice and management has been brought to a state of perfection which brings the price of a high class economical pumping engine down to a point justifying the use of a very high steam economy, a much better engine can be installed than most people would buy a few years ago. An engine in which is combined simplicity, high efficiency, great durability and compactness; in fact a high type of engine is now used in the comparatively smaller capacities, which not long ago were left to the field of low economy and low interest account. There was a time when a pronounced contest was waged, between high cost and high economy on one hand, and low cost and low economy on the other. But now the extremes are brought nearer together and finally blended into a still higher economy than ever before at a moderate cost in proportion to the results obtained. It may be that profits are less; but production is certainly less expensive; several factors no doubt combining to help the buyer.

Let us map out a course which would be followed, indeed has been followed, with very satisfactory results, whether the purchaser be a private corporation or individual, or a city hedged about by legal requirements in the making of a contract. First it could be stated in some sort of an announcement that the proposals will be received at a certain hour, date, and place; and putting all upon an equitable footing with sealed proposals. The matter of check, generally a rather large one, accompanying the bids, is at most times open to criticism, and most generally of no practical use; in a collection of bidders it would be difficult to find any one of them imbued with the idea of running away if the contract should be awarded to him. In fact, some of the most skillful, and untiring, efforts are put forth to secure such contracts, with the feeling probably uppermost that the check on deposit would be cheerfully given up to secure the work rather than to avoid taking the contract. It is safe to say that in the pumping engine business, a concern once making up its mind to submit a proposal, the needs of a check or a deposit to coerce the bidder into taking a contract would not arise once in a hundred times. Of course it may be urged that such a check will keep out weak or incompetent bidders, but the records do not bear out this idea, for the simple reason that really very few such apply for work. The actual history of the letting of contracts for pumping engines for public water supply, shows that from time to time a new Richmond enters the field, and immediately all those who have been in the business for some time, express disdainful sentiments as to the ability of the newcomer to meet such a contract. The newcomer is promptly dubbed "an under dog," and so he is too, for the time being. But the "under dog" finally gets a part of the game, and as time rolls on he becomes one of the regulars and in his turn elevates his nose at some new fledgling appearing upon the scene. It is rather amusing to look back and recall to mind some of these "under dogs," as they were called, and consider what large, fierce, and strongly developed mastiffs they have grown to be to-day; and further than that, they seem to be hunting in packs at the present time. A list of the "under dogs," the mastiffs, and finally the pack, would divulge some very familiar names to

many members of the water works association.

General data should be stated for the information of the intending bidders, arranged in a convenient form so that those at a distance need not go amiss in preparing a proposal, or put under the actual necessity of sending some one to investigate. Cases of course differ; whether the machinery is to go into an old building or a new one is to be built for its accommodation, so it may not be practicable to lay down a hard and fast rule; but the general data from an actual case may give some ideas of the requirements:—

Static water pressure at level of engine room floor.
Static water pressure from floor to level of water in well.
Allowance added for friction in force main.
Allowance added for friction in suction pipe.
Total working load upon plungers.
Steam pressure at throttle.
Available clear height above engine room floor.
Engine room floor to basement floor, vertical.
Available distance across engine room.
Wall to wall of engine room, inside, across.
Available on floor, lengthwise of engine room.
Available in basement lengthwise of engine room.
Distance from building wall to pump well.
Air chamber required at inboard end of suction pipe.
Air pump required for force main.

Then it seems to be desirable to state at least closely approximate, the required length, or the stopping place on the contractor's part, of the suction, delivery, and steam pipes. And in this and other items remove to the utmost extent any and all uncertainties, so that builders of pumping engines may be able to figure upon some exact basis. In fact a clear and comprehensive statement of the work which the buyer wants done will help greatly in the matter, and save a great deal more money than it will cost to make such a statement. A general outline of the work to be done, modified of course by conditions in different cases, would call for the making of the design, furnishing general and detailed drawings or blueprints, and erecting in the pumping station, upon foundations to be furnished and built by the buyer, in accordance with the detail blueprints,

templates, and anchor bolts, furnished by the engine builder, a pumping engine of the desired class or type together with appurtenances, connections, piping and fixtures within the engine room, complete ready for continuous service.

A call for detailed drawings or working plans of a pumping engine by a buyer is not looked upon favorably by some bidders, as it is considered to be rather an exposure of trade secrets, but in some cases of public work there is a legal requirement to the effect that all details of a contract must be made public and submitted, at least so far as the Board or other public body officially making the purchase is concerned. At any rate, even if the detailed drawings should be suppressed, a clever draughtsman could produce upon paper a very close imitation of any machine in operation, which might be open to public observation which as a rule water works engines are. And in addition to this opportunity for copying, the technical journals publish, from time to time, notable specimens of all kinds of engines and machinery nearly enough in detail to afford a pretty good guide as to capacity, strength, and minutia of construction.

Some of the first things needed to be known by the builders are the conditions of service under which the engine is to operate. This can be conveniently made known by stating the number of gallons required to be pumped per 24 hours, giving the total water load upon plungers, including friction of suction and delivery mains, static head, point and manner of delivery of the water, and making this statement in a positive manner, releasing the engine builder completely from all responsibility for the details making up the total load, but requiring of him an engine capable of delivering the given quantity of water against the aggregate working pressure under the stated conditions.

The methods of determining the capacity of the main pumps vary according to the ideas of the builders and buyers; sometimes a weir only; sometimes a weir in conjunction with the plunger displacement. The writer has reached the conclusion that with proper pump construction, the plunger displacement is adequate and conclusive, care being taken that the pump valves are reasonably and practically tight under pressure and

of a design including their seats, which will place their capability of holding water beyond doubt. When it is realized how much work and carefulness is necessary in constructing and arranging a suitable weir, taking care of the velocity of approach by conciliating the various ideas upon that point from sincere but differing students of the subject; guarding against leakage and numerous errors and erraticisms to which carelessly or difficultly made weirs are subject; to say nothing of the losses from force mains carrying the water to a reservoir perhaps a mile or more away from the pumping engine; when all of the possible errors of weirs are considered, the clean cut, unmistakable performance of multiplying the actual areas of the plungers easily measured, by the length of the stroke also easily and accurately determined, will be found to be much preferable; especially so when it is considered that an excess allowance of say five per cent. in plunger area can be provided to make up for possible deficiency at the stated speed of travel, so as to ensure the actual quantity called for. In short, with a properly made pump measuring the water at the very point of delivery with all discrepancies of leaking pipes eliminated, there could scarcely be so good a measure of the quantity of water pumped, in fact, such a pump will no doubt come within one per cent. of the calculated capacity of the plungers in the real delivery of water. Such pumps can be made, and, even if it should cost a little more money to have them, any such excess over the price of a badly designed pump will be trifling compared with the constant always present loss day after day of coal burned under the boilers, and a considerable discrepancy in the amount of water going up the hill.

In the matter of design of a pumping engine, under specifications drawn closely enough to indicate the type desired clearly and unmistakably the actual design may be well left to the builder; the stipulation being made that the engine if to go into a building already in existence, must conform reasonably to its proposed surroundings, so that proper and convenient space about its various parts may be assured. In the matter of adapting this or that general type of machinery to any particular work or service perhaps the buyer

might profit by independent expert advice, so as to guard against the well meaning but misguided zeal of makers possessed with strong desires of selling machinery which might not possibly represent the very best investment for the buyer, but which might incidentally give its maker and advocate some trifling advantages over competitors in making a contract.

A fairly good general statement of what would be desirable in a pumping engine for most cases, and provided there were no special reasons otherwise, would be about as follows:—

To have the steam pistons rigidly and directly connected to the water plungers so that no power would be transmitted through working parts and joints beyond that due to the equalization of the steam distribution.

The steam cylinders and the pump cylinders connected and supported so that the engine would be practically self-contained; and have all anchor bolts extend downward far enough into the foundations to obtain the benefit of the weight of the masonry.

There is no good reason for not stating the stroke of the pistons and plungers, and their speed as well, either or both in feet of travel and revolutions per minute, giving the allowance of excess desired in the plunger capacity. The buyer might just as well place all competitors upon an equal footing, leaving very little to argument or uncertainty, and he will find that, much the easiest and more economical way for dealing with the matter. Subterfuges relating to percentages of plunger diameter to length of stroke are sometimes indulged in for the purpose of stipulating dimensions, but by far the better way is to come right out with the desired proportions of the water end of the machine conforming of course to good practice, but leaving the steam factor largely to the builder on account of the duty guarantee generally required. The writer has observed cases wherein it would have been much better to appoint the experts before the buying of the engine than to wait until after completion for the regulation test of the machinery; and for the reason that, even where the designing is left to the builder, certain stipulations covering principles of construction and propor-

tion if properly carried out will ensure the results asked for by the buyer, and all the experts would need to decide would be whether or not these stipulations had actually been met; a test much more readily and decisively accomplished than some of the ends aimed at during duty tests after construction. For example, we know that a pumping engine at a given speed, with certain diameter of plungers and length of stroke, will, when properly made, displace just so much water; the construction and workmanship being the guide as to capability. We also know from records and experience that certain proportions and construction of steam cylinders and appurtenances will perform safely, certain economical efficiencies; the entrainment of water in the steam, or the leakage of a force main between the engine and the reservoir will not have any bearing upon these facts as points of design and construction in the engine. If the buyer is suffering from bad boilers and force mains, the engine builder can not help him out by modifying his machinery. Give the engine builder dry saturated or superheated steam for his engine or the equivalent allowances therefore, and then take the water away from his pump under the stipulated load, and that is as far as he can fairly be held responsible for results.

The condenser for the engine comes in of course for some attention, and whether of the jet or surface type depends upon the situation, from where the condenser water is to come, and other considerations applicable to each case by itself. If a jet condenser is used, the injection water should be taken from a point and under conditions, which will ensure a solid column of water containing the natural minimum percentage of air. Difficulties have been run into from time to time by attempting to save something in the length of injection pipe, on account of the disturbances and conditions which usually are found in main suction pipes. The writer recalls to mind three well developed cases, where trouble in getting sufficient vacuum followed the attachment of condenser injection to main suction pipes, and where the trouble with the vacuum was removed by modifying the arrangement of the pipes carrying the condenser supply.

As a broad principle, the water for a jet condenser should be taken from the main pump well by an independent pipe or pipes for the use of the condenser exclusively; and if this can not be practicably done then the nearest possible approach should be made to such an independent arrangement. With properly proportioned injection pipes the vacuum in the condenser will always be sufficient to draw the water from any point possible to be used by the main pumps of the engine.

The air pump or pumps with the speed as moderate as a pumping engine, better be driven from the main engine unless there exists some special reason to the contrary; in fact, general economy points to the driving of all auxiliary pumps from the main engine as a broad principle. The question of an exhaust feed water heater between the low pressure and the condenser depends for the most part upon surrounding conditions, but it will generally pay to use such an appliance.

The steam cylinders and all piping connected with the engine together with the receivers and all other parts where radiation of heat will represent loss, should be covered to prevent radiation, and where practicable or desirable to do so lagged with some suitable material.

The various parts of the machinery should be of plain and substantial design with appropriate shapes and forms adapted to the special purposes; the principal aims being for ample strength, great reliability, good mechanical effects, etc. Where the design is made by the builder, there is not very much to say when the work is in competent hands; but there is no harm for the buyer or his representatives to know that the bed plates and framing should be designed so as to prevent loss of alignment, or undue strains, or changes of load distribution, from variations of temperature or other causes; castings so designed as to avoid objectionable changes of section with reference particularly to shrinkage strains; reinforcement of the body of the casting next to flanges, proper fillets, round corners, re-entering angles and all such details which may just as well be had at the same price as something less desirable; the desirable machinery

coming as much, or more from a thorough knowledge of design and construction, than from an advance in price asked by the builder.

The steam cylinders to be thoroughly steam jacketed, and all steam distribution valves so designed and located that the steam and exhaust ports are correctly proportioned to cylinder volume and piston speed, affording easy induction and release of the steam with the least friction consistent with minimum clearance. There are examples of close clearance where the waste room in the cylinders have been brought down as low as the following percentages:—

High pressure cylinder.....1.4 per cent.
Intermediate cylinder ..... .6 per cent.
Low pressure cylinder..... .5 per cent.

The above clearances are about the lowest known and are found in some of the well known three cylinder vertical triple expansion pumping engines.

The construction and arrangement of steam jackets so as to prevent or avoid undue strains and tendencies towards leakage, is very important, and it is pretty safe to say that there are few adjuncts of the steam engine requiring so much attention and careful thought both by the builder and the operator in proportion to the benefits derived, as the steam jacket; it is really a necessary nuisance.

The receivers with heating coils, situated in the track of the steam in transit from cylinder to cylinder, should be of liberal dimensions so as to distort the steam distribution as little as practicable; and in fact the distribution of the reheating steam throughout the jackets and receiver coils should be brought to and carried at a point which will give the most economical temperature to the working steam at the different points and pressures, keeping the working steam as dry as possible and avoiding so far as practicable the sending of superheated steam to the condenser.

The general construction and arrangement of the pumping engine, will of course depend upon whether it is horizontal or vertical, as either one of these distinctive types will follow lines peculiar to itself; also depending whether the type will be rotative or non-rotative, that is to say, crank and fly

wheel, or, direct acting. Bed plates where used should be proportionately deep and massive, and of design to permit the framing to be of substantial spread and strength; stationary members should where possible be of the box or hollow girder type, and with simple outside forms; symmetrical, appropriate and neat; exhibiting due relation to other things about the engine. Main pillow blocks where used, are as a rule preferably made as a part of the bed plate, and having proper caps formed with outside lips so as to tie the pillow block shoulders firmly together. The structural connection between the steam and the water ends of the engine should be so as to make the machine as a whole, self contained with reference to the working strains and the lines of resistance; the hold of the anchor bolts upon the bed plate, framing or other parts to be by means of massive bosses or hubs cast solidly with and as a part of the member to be secured; the tops of the bosses and the bottoms of the anchor bolt plates to be faced, and anchor bolts provided with faced washers and nuts of heavy pattern both at top and bottom.

The main pumps constituting the water end of the machine, are made in various ways and to suit the general design; but it is a good rule to follow plain forms and arrangements with pumps. The normal action of a pump taking and discharging water is an extremely simple one, as natural as an animal breathing and indeed almost the same sort of a performance. So that it is important to have ample water ways of easy and natural shapes, obstructing the flow as little as possible, and conforming to the known characteristics of water in motion as far as may be, thus aiding to raise the mechanical efficiency of the pumping engine as a machine doing work, to the highest attainable point; examples may be seen in which the mechanical efficiency is as high as 96 per cent.; that is, the work accounted for and shown as useful, amounts to 96 per cent. of the total indicated steam power developed.

The pump valves are of course highly important details, and in general practice have been brought down at the present day to plain rubber discs, rather hard and of moder-

ate size, supported by brass gratings of circular form, with radial ribs to support the centre of the seat. There is, however, a new pump valve just appearing which consists of a corrugated brass or steel diaphragm connecting together an outer and inner narrow ring of rubber or soft metal, so arranged that the radial bars of the valve seats are not touched by any part of the valve, the shut off being made at the outer and inner circles of the seat by means of the narrow rings; thus entirely eliminating the principal cause of the destruction of pump valves, the bearing upon the radial bars. These valves are not yet enough in evidence to know exactly how they will act in continuous service, but the writer hopes to demonstrate them one way or the other within a few months in a large pumping engine now under construction.

The area of pump valve openings is a subject which has led to many arguments and disputes during the development of pumping machinery; the reference often being made to percentage of plunger area in denoting the aggregate "valve area" of the pump. But the valve area by itself, that is, the number of square inches of opening through the valve seats, will not answer the question in relation to the plunger area. The valve area is a factor of the quantity and really independent of the incidental area of the plunger; and as a matter of fact the flow of the water through the valve seats must not go above a certain velocity if proper operation of the pump is to be retained. Therefore the relation between the quantity of water and the area of the valve seats with a limit of velocity held in view, really controls the aggregate of the openings, and any one who will take the trouble to figure it out will find that it matters not whether we consider a small plunger at a high rate of travel or a large plunger at a slow rate of movement, which means that so long as the quantity per minute and the valve area remain constant the changing of the plunger will matter but little. If we go to talk about valve area in terms of percentage of plunger area, the speed of the plunger must be considered, and this has led the writer to a pretty good rule to govern in such cases; which is to divide the feet traveled by the plunger per minute by two and let the result represent the percentage of the plunger area for the valve seat openings. For example:—

Plunger speed per minute in feet.	Percentage of plunger area in the valve seats.
100 feet.	50 per cent.
150	75
200	100
250	125
300	150

This will keep the quantity of water, the valve seat opening area and the velocity of the water through the seats practically in constant relation, which of course keeps the movement of the water under constant conditions and ensures the proper operation of the pump. Of course the large pumps will have some advantage over small ones under this rule, or in fact under any rule of a constant nature, for the reason that the valve seats will enlarge a little in large machines and then the area of the openings will be greater in proportion to the friction surfaces.

The moving parts of a pumping engine should have strength and stiffness to avoid tremor and vibration while at work; the steam pistons should be light and strong with liberal bearing surfaces, and self adjusting packing; the latter day requirements calling for polished faces both for the pistons and the inner surfaces of the steam cylinder heads to reduce the radiation to the lowest possible limits. The piston rods are made and attached in various ways and of slightly different material, but the most favored probably are of forged open hearth steel with about four-tenths per cent. carbon; highly finished all over and not draw filed. They are attached to the pistons sometimes by forcing and sometimes not; generally in large engines secured by a nut or key. Builders of good repute follow slightly different methods but they all seem to arrive at satisfactory results. The piston rod is a beautifully simple detail, but it can be made badly at times even at considerable expense. The piston rod packing is generally in these days of high and dry steam, of the semi-selfadjustable metalic construction; the perfectly cylindrical parallel form of the rod coupled with high polish and finish, when such is obtained, going a long way towards the long wear and good service of the metallic packing; in fact it pays a large profit to the buyer to have some

money spent upon the character of the piston rod.

In the better practice forged steel cross heads are used where practicable or appropriate; having the piston rods a close fit in the sockets and secured by means of forged steel nuts of extra depth in proportion to diameter. Cast steel cross heads are also successfully used where a competent metal properly annealed may be obtained.

In crank and fly-wheel pumping engines the economical production of the very highest quality of solid open-hearth steel forgings, and centre forged steel details for steam machinery is gradually bringing the grade of various parts of pumping engines up to the highest known levels for such work. Although costing a small percentage more than wrought iron, the very best and really cheapest material for piston rods, connecting rods, crank shafts, cranks, distance rods, and other details of like nature is steel, forged under hydraulic pressure from clean, sound ingots somewhat larger in mass than the finished product, and the piece properly annealed. Such forgings not infrequently have a tensile strength of over 80,000 lbs., and an elactic limit of 50,000 lbs. with an elongation of 25 per cent. before parting under test.

Open hearth furnaces with temperatures of about 4,000 degrees F. are used for steel ingots necessary in making such shafts, rods, etc. The forging is mostly done in hydraulic presses at quite a moderate rate of "squeezing" which allows the flow and adjustment of the metal to take place. Sometimes a gross pressure of from 12,000 to 14,000 tons are employed in this hydraulic forging process, and from 400,000,000 to 600,000,000 foot pounds per minute are developed; the actual force in the pressure pumps reaching at times as high as 6,500 lbs. per square inch. During this process of forging a hollow steel shaft inside and out, the material is thoroughly compacted, as the mandril almost filling the hole in the ingot serves as a sort of anvil and a succession of pressures take the place of blows; the process being materially assisted by the advantages in heating a hollow cylindrical mass, instead of a solid one. The undesirable qualities in the fluid compressed steel ingot are in the centre, and after the original casting of the ingot is made, the defects are bored out after cooling, and the sound

piece in the form of a short thick cylinder is reheated for forging; so that the material which is actually worked upon for the finished product is practically homogeneous. Solid forgings are often used instead of the hollow forgings described above, and very good material may be produced especially of the dimensions practically used in pumping engines. Some work of this character for a large triple pumping engine was tested by the writer during the past year with the following results:

No. 1,	Elastic limit	35,300 lbs. sq. inch
	Tensile strength	76,250 " "
	Elongation	26%
	Reduction of area	39%
No. 2,	Elastic limit	35,150 lbs. sq. inch.
	Tensile strength	77,950 " "
	Elongation	27%
	Reduction of area	37%
No. 3,	Elastic limit	33,250 lbs. sq. inch.
	Tensile strength	75,350 " "
	Elongation	27%
	Reduction of area	37%

The cranks are also very important members of the construction, and are made of cast iron, wrought iron, or steel according to circumstances and the ideas of the designer; cranks are sometimes forced onto the shaft by hydraulic pressure, and sometimes shrunk on. The fly-wheel hubs are also subjected to the same treatment, mostly forced on when the wheel is made with a centre instead of in halves as is sometimes done. The gross pressures used in some cases aggregate from 200 to 300 tons. The cranks and wheels should of course be securely keyed after being forced into place.

The mechanism pertaining to the steam distributing valves, is a most important detail of the engine and should be of great strength and durability, so as to be thoroughly reliable in all its functions and motions,, free from failure and derangement. In these days of the use of large poppet valves, both induction and exhaust on the low pressure cylinder so as to reduce the clearance or waste room to the lowest possible dimensions for this last cylinder before the steam escapes to the condenser, there seems to be a tendency to make some of

the connections too light, apparently with the idea that the work of moving poppet valves, very nearly balanced or at least under very light pressure, is next to nothing. But the comparatively large size and considerable weight of the poppet valves employed, together with the actual lifting and bodily moving such valves and their rods, calls for a stiffness and strength in main valve gear connections, sufficient at least to prevent undue tremor and actual breakage. There seems to be a temptation among makers of machinery, because some certain parts of a machine, to all appearances are situated so as to carry a light load, to practically take the ground that such parts have "nothing to do," and make them correspondingly light. But it will not require very extended experience to observe that these things which "have nothing to do" are the very ones which break down the most.

The valve motion connections to and from the eccentrics, rock shafts, wrist plates, and valve arms, should be adjustable for lost motion, and wherever necessary or desirable, also for length. The methods for the adjustment of the valve motion pins and bearings should be consistently carried out by means of some kind of solid heads either of composition or steel, and where expedient or desirable, by means of straps and keys. But all working rod joints should be adjustable for wear by the use of half boxes adjustable by means of set screws, wedges or keys. The radius rods where used should be screwed into the wearing heads by right and left threads provided with jam nuts or the equivalent.

In the older practice many valve stems were made of hard brass, but in these days of high initial pressure, and with the general large increase in dimensions and powers, forged steel valve stems have come into vogue, protected where necessary by brass sheathings and arranged to drive the valve by strong, adequate, and reliable means of contact. The valve stems, whether for the Corliss type or for poppet valves, should be well guided at or near the outer ends in substantial bonnets or brackets, and be provided with competent stuffing boxes. With rolling stems there is probably no objection to proper internal shoulders or collars on the valve stem, but in any event there should be stuffing boxes provided.

The steam distribution valves themselves should be of an extremely reliable type in a pumping engine for water works service and have proper facilities for refitting and adjustment; the engine in most cases being fitted with a variable cut-off mechanism so arranged that it may be easily and promptly manipulated from safe and convenient points while the engine is at work. In the vertical triple expansion machine now so generally favored, the cut-off on the high pressure cylinder is controlled by an automatic governor, and also adjustable by hand. The intermediate and low pressure cut-offs are adjustable by hand only, and in some cases the low pressure, both cut off and exhaust, are fixed and not adjustable excepting by changes of a permanent nature.

The valve motion, throttle valve, and other starting mechanism should be so that the engine could be promptly and conveniently started, stopped, and generally operated by one attendant from the main floor of the engine room or from any of the galleries or platforms usually provided. There are also points to be looked after carefully, pertaining to journal boxes, their adjustment and lubrication, arrangements for manipulation with the least practicable delay; and other proper qualities of such important details.

The materials entering into the construction of a pumping engine for public water supply, should be of the best quality practicable to obtain, and by proper attention to this portion of the subject very acceptable results may be obtained under the ordinary methods of competition. And, as this portion of the subject is a very important one, in its general bearings, the writer will follow rather closely the lines followed in a good class of specifications, taking up successively, the various kinds of material used in the construction.

The iron castings should be free from blow holes, flaws, cold shuts, blisters, and defects of any and all descriptions. Soft spots left by core chaplets to be completely remedied and obviated if occurring; and the buyer of the machinery should have the right to reject any and all castings not thoroughly sound and which may be discovered to be fractured or otherwise damaged or defective after the engine is erected. The castings should be smooth and true to form, sound, of tough,

strong material and of proportionate dimensions.

The cast iron used in the steam cylinders, steam distribution valves, and the pump plungers should be close and fine grained, hard as can be practicably worked, uniform, and with good wearing qualities.

The framing, flywheels where used, pump bodies, and other fixed parts should be of a first class machinery mixture, possessing a tensile strength of at least 20,000 lbs. per square inch.

If there are any steel castings used in the construction, they should be thoroughly annealed, and have a tensile strength of not less than 60,000 lbs. per square inch and not more than 65,000 lbs. per square inch; and have an elongation of 15% before parting.

All steel forgings used in the construction should have a tensile strength of not less than 75,000 lbs. per square inch, an elastic limit of not less than 35,000 lbs. per square inch, an elongation of not less than 25%, and a reduction of area of not less than 35%, all of the above mentioned requirements based upon standard samples and methods.

All wrought iron used in the construction should be tough and uniform in character; and specimens broken in a testing machine should show a tensile strength of at least 55,000 lbs. per square inch, and an elongation of 15% in eight diameters.

All rods should be formed, whether rolled or forged, in one homogenous, continuous piece without weld. Any evidence of a weld in such pieces should subject same to rejection from the work.

The composition metal used should consist of the best quality of new material only, of a mixture or mixtures specially adapted to the particular work in each case.

The babbitt metal used should be of a quality which will show upon analysis to be that required with reference to the percentage of pure tin, percentage of antimony, and percentage of copper; and the buyers should have the right to have such analysis made whenever desired, but at the buyer's expense.

All rivets used, if any, should be made of the best refined iron, and should be capable of being bent cold until the sides are in close contact without any signs of fracture at the convex side.

All of the material used in the pumping engine should be subject to inspection, analysis, or tests, subject to the approval of the buyer. But no allowance for any such inspection, analysis, or tests should be made by the parties figuring on the work, the buyer bearing all such expense when they become necessary.

At any time during the construction of the machinery the buyer should have the privilege of calling for test pieces of the various materials entering therein; the contractor thereupon preparing and supplying such pieces to the buyer in the number, shape, finish and size required. But the buyer should bear the expense of preparing and testing such samples, with the understanding, however, that the contractor may have a representative present when such tests are made. The cost and expense of preparing and testing such samples of materials is placed upon the buyer for the purpose of simplifying the estimations upon the work at the time of bidding; as many times such sampling and testing may not need to be done or wholly done, on account of favorable or satisfactory conditions surrounding the execution of the contract, and in which case considerable incidental expense could be saved the buyer, who would, of course, eventually be made to foot the bill, no matter how arranged; therefore if it could be made clearly apparent by other means than expensive testing that the work and materials were satisfactory for the purposes in view, a good portion of the testing might be dispensed with.

Regarding the design, workmanship and construction of the pumping engine, together with its erection at the place of use, its finish, appurtenances and appointments, it would be sufficient to stipulate that in the above-mentioned particulars the machinery must conform with the best manufacturing machine shop practice as carried on in this country, and must be satisfactory to a reasonable extent to the buyer under a fair interpretation of the specifications under which the work is awarded. Special reference might be made to the following items:

Bearing surfaces of sole and bed plates.
Design, fitting and securing of fly-wheels.
Bolting of bed plate joints.
Boring of steam cylinders.
Particulars concerning flanges, lathe centres, etc.

Steam and water joints.
Steam and water gates and valves.
Turning of journals, fitting of bearings, etc.
Straps, gibs, keys, reamed bolt holes, bushings and rods.
Machine tool work.

Other important details desirable to have in mind with reference to good workmanship and design, would be gear wheels where used, permitting nothing but the best class of cut gearing; the working faces of cams, latches and parts of the valve gear where subject to intermittent or sudden motion and constant heavy wear, should be of tempered steel, and of accurate fit and form after being hardened and put into place; the taper and fit of dowel pins, with facilities for removal where necessary; the accurate and true fitting of keys and the proper forcing or driving of same into place, proper size and taper, and providing keys intended to be withdrawn when necessary with appropriate heads; finish and polish of connecting rods, links, radius rods, valve rods, visible composition work, exposed machine work, and other details.

The best makers design and do their work so that all parts of a pumping engine are well secured and correctly centred and aligned with well-fitting dowel pins, bolts fitted to reamed holes, or male and female points; with flanges cast solid and with all bolt holes drilled; flanges counterbored or spot faced around bolt holes to a uniform thickness; all rivet work properly designed for its use and purpose, and all riveted joints subject to pressure thoroughly well and neatly calked with a round nosed tool. Nuts and bolt heads and all threads should be of the U.S. standard, excepting, of course, where special threads are necessary; the threads and shanks of all bolts above $\frac{5}{8}$ of an inch in diameter should be turned and cut in a lathe or special bolt machine, and finished with neat spherical ends; case hardened and finished nuts used in all exposed work above the operating floor or gallery, and also on all parts requiring frequent removal and adjustment; nuts and bolt heads for stuffing boxes and other necessary places finished; cold pressed nuts used for all stationary parts of the pump chambers and similar places; all nuts and bolt heads should be hexagonal in shape

and faced on top and bottom, square with the axis of the bolt; the sides to fit the wrenches accurately.

Non-conducting material, or false covers should not be applied to a newly erected pumping engine until the construction has been well tested by working steam pressure and all leakages and defects completely remedied. Then after the various joints and parts have been shown to be steam tight under working pressure, the heat surfaces, where radiation would represent a loss of useful heat, should, of course, be protected by suitable and acceptable covering, and where practicable or desirable an outside finish of lagging applied; the type of lagging now much in vogue being heavy sheet steel securely fastened to appropriate framing and flanges, and held in place sometimes by bands of polished metal, or round headed brass screws or both, the steel lagging either having a finish by planishing the surface of the metal or by painting. The old-time wood lagging, generally of black walnut, seems to be passing away, although as a matter of appearance will probably never be excelled, even if not quite so durable.

In drawing up specifications for pumping engines upon the part of the buyer, it is not good practice or policy to go too closely into actual design or even dimensions, but rather, set forth the conditions and requirements to a pretty exact degree, and by so doing the competition will be kept within certain restrictions, a good, close, and real competition on figures will be obtained, and a great variety of bids on machines, most of which would not be wanted, kept from complicating the efforts to secure the class or type of machine really wanted and best adapted to the work to be done in the current service of the water works plant.

The writer can recall a recent case, where in ten or twelve bids from different concerns representing the best manufacturers of pumping machinery in the country, with business headquarters situated hundreds of miles apart, the dimensions given by the bidders for the machinery proposed to be furnished were alike in a large majority of the offers, and even the few which differed from the majority differed but slightly. The bids reduced to equal terms did not vary more than 5 per cent. In the specifications under which all of the proposals

were made, not a dimension excepting the length of stroke of the engine was mentioned, but the conditions of service were pinned down so closely that practically all bidders arrived at the same conclusion.

A case of opposite character is also recalled, where the writer was called in to untangle a snarl of bids; the highest being more than a hundred per cent. above the lowest. This condition being the result of a wide open specification of very indefinite meaning, and wherein very few particulars were given. The bids were all rejected and a new specification resulted in a good clean competition with figures about two-thirds of the highest bid received under the first call.

After the contract is closed and work upon the part of the builder begins, he should construct and erect in the shops all of such parts of the machinery as may be necessary to ensure the final construction at the destination with reasonable dispatch, in a thorough and satisfactory manner. The mistake is sometimes made of leaving too much of the work which ought to be done at the shops to be performed at the place of final erection, thereby causing increased expense and delay; of course it will not answer to assume too much dictation towards the contractor on account of the guarantees and restrictions under which he is working and on account of the responsibility he assumes under the contract; at the same time there is a great difference in the handling of such work, and the buyer must be clever enough to expedite matters all he possibly can without infringing the legal rights of the contractor. In any kind of a quarrel the contractor generally has the long end of the lever from the legal standpoint, but there is generally a smooth way to carry out contracts if reasonable tact is exercised, but of course tact and equity must not stand too much in the way of the buyer's rights.

The specifications under which the work is let should provide for the carrying out of the contract in a clear and comprehensive way, and the various items appropriately arranged and expressed under different heads are suggested something like the following, depending of course upon the special features of the case:—

Transportation of the machinery at contractor's risk and expense.

Contractor to provide necessary cranes and derricks.

Buyer to furnish space for reception of machinery.

Buyer not responsible for safety of machinery until acceptance.

Contractor to make good damage to buyer's property.

Buyer to furnish foundations and all masonry work.

Buyer to furnish all pipes outside of building.

Buyer to paint the machinery at completion.

Contractor to replace injured parts during construction.

Contractor responsible for injury to person or property.

Time of completion with bonus and penalty.

During the past twenty-five years there has probably been nothing concerning the capabilities of pumping machinery so much and variously discussed as its economic duty; or, the ability or inability to develop more or less foot pounds of work upon one basis or another of comparison, mostly per thousand pounds of steam consumed, or per million heat units utilized. Twenty-five years ago 60,000,000 foot pounds duty was a general guarantee for water works engines, with occasionally an engine of special design aiming to show 100,000,000 foot pounds, the advocates of the higher type and more costly machine arguing that the saving in fuel represented by the greater economy would more than pay the interest upon the difference in cost of the machinery. This saving was a fact, upon the showing of the returns provided the engines were equal in other respects, principally as to the ability of the machine to successfully and continually pump water without unusual interruption on account of stoppage and break down and needed repair. Years ago, the writer of this paper took the ground that the first duty of a pumping engine is to pump water and sees no reason to change that idea to-day; but in the early days of higher duty than about 60,000,000 foot pounds, the engines were not built as a rule quite so sturdy for the hard work of pumping as their lower duty competitors, and if durability, smoothness of operation, and decreased cost, had not gradually forged to the front, in the construction of pumping machinery for water works, the present admirable results would not have been attained and reached so high a level as at present.

The expansion of the steam is the key of course to higher and higher economy, but as this factor was increased in ratio from time to time and gradually approached its physical limits, new difficulties arose one after another, or were more and more realized as greater attempts at higher economy were made; but after persistent efforts along encouraging lines the happy compromise seems at last to have been obtained between a highly elastic fluid at one end of a machine, and a non-elastic most stubborn fluid at the other, and with the limit of steam economy very nearly reached. In the early days of steam expansion to high ratios, it did not at first seem to be realized that the impact upon a steam piston of a very high initial pressure as against the corresponding effect of a lower pressure, would greatly increase the shocks and possible damage to the machine.

For example, with a 30 inch steam cylinder working condensing, indicating 40 lbs. mean effective pressure throughout the stroke; in one case using 100 lbs. steam pressure with 8 expansions, the initial load upon the piston would be 33,770 lbs., while in another case using 70 lbs. steam pressure in a throttling engine, the initial load upon the piston would be 24,560 lbs.

With 100 lbs. initial pressure and 10 expansions the mean effective pressure would be 33 lbs. net, with an initial load of 33,770 lbs. as before, but the initial piston load upon the throttling engine to produce the 33 lbs. mean effective pressure would be only 21,490 lbs.

With 125 lbs. initial pressure and 15 expansions the initial piston load would be 41,445 lbs. with a mean effective pressure of 30 lbs., while the initial load upon the piston of a corresponding throttling engine would be only 18,420 lbs.

This enormous difference in impact of initial pressures, coupled with the great amount of internal condensation within the steam cylinder when too high a rate of expansion was attempted in one cylinder, had a powerful effect in bringing about the very great extent to which the load is distributed throughout the machine as a purely mechanical problem; also the thermal idea of dividing the expansion into different stages and so reduce the range of temperature in each of the cylinders

employed. Added to this, the result of repeating a single type of construction after the maximum efficiency had been reached, enough times to establish an economical rate of manufacture has been to produce the commercial pumping engine of to-day. In large engines, and under good boiler conditions, yearly duties are maintained as high as from 120,000,000 to 135,000,000 foot pounds per 100 lbs. of coal burned; and, of course, it must be borne in mind that no matter how high a steam efficiency a pumping engine may show, the results at the boilers in producing the steam have a controlling influence upon the yearly reports upon economical operation.

For example, with a pumping engine giving an indicated horse power with the consumption of 12 lbs. of steam per hour, the actual duty in coal consumed would be as follows:

With 8 lbs. evaporation in the boilers, 120,000,000 duty.
With 8½ lbs. evaporation in the boilers, 130,000,000 duty.
With 9 lbs. evaporation in the boilers, 135,00,000 duty.

The complaint has often been made that pumping engines do not give so high a duty in regular service as upon the test with experts. In general terms this must be admitted and because the experts know how to adjust the engine and operate it to comply with the conditions found to exist, better than the attendant usually found in pumping stations; and this difference in operation in favor of expert work is because the expert by his more extended knowledge of the subject is a more valuable and a higher paid man than the regular attendant as a rule. But it would not pay for all the difference in economy to employ scientific experts to operate a pumping station, although for purposes of contract comparisons the very best work of the engine is sought to be brought out by the contractor, and this is just what the expert does, leaving it to the regular attendant to approximate as nearly as possible under every day conditions and multitudinous cares, the pace set at the regular test. But aside from the fine adjustments which the expert is able to make in the engine so as to completely adapt the machine to its work at the time of test, and while the engine cannot be expected to keep up to the fine adjustment in the hands of its regular attendants, any material falling off in duty can be traced to changed operating conditions.

With a properly designed and well-built machine, its actual steam economy should be maintained at very nearly the maximum, and no doubt it is, in a great majority of cases, in fact, unless cutting or other damage to its valves and pistons take place the initial efficiency cannot be lowered very much without gross inattention, or without a very serious departure from the steam and water pressures for which the engine was built. But where, as in the usual annual report of the water works superintendent, the statement of duty is in terms of coal, it will be seen at once that there are a good many chances for losses of various kinds. When operated under good conditions there is not very much difference in boilers so far as efficiency is concerned, but when boilers are worked under bad conditions there is a different story to tell. There are three prominent items affecting the actual coal duty of a pumping plant pertaining to the boilers; they are overworked boilers; underworked boilers, and various kinds of coal. And for these shortcomings the engine is not responsible.

Another reason why pumping engines sometimes fall short in duty in regular service, is that they are not always properly proportioned to the work to be done. This cannot be helped sometimes; the future must sometimes be reckoned for, and when an engine is put in, it must sometimes be larger than present needs demand. but the contractor is entitled to test under the best conditions for which the machinery is built, and therefore when the experts get away and the machine put into the regular service, the ideal conditions are destroyed and unfavorable conditions substituted. Chicago had such an experience some years ago; the engines advertised for were to pump against a head about 50 per cent. greater than really developed in regular service, with the result that triple expansion engines were placed under conditions where compound engines of a smaller steam end would have undoubtedly done much better work. No comments are attempted to be made upon the facts; it is only used as an illustration of how disappointment may be met with even though a high type of machine may be secured, and further illustrates how a duty test run by experts under proper conditions, may be greatly discounted in every day operation, and where "somebody blun-

dered" but where the engines and the experts were not to blame in the premises.

The adaptation of a pumping engine to its conditions so far as may be, is the key to highest efficiency under the conditions. imposed. There are advocates of high speed, of high steam pressure, of high rate of revolution, and other singled out and isolated factors, but the general combination wherein the machine best meets the conditions is what will yield the best results, and not the exploiting of any particular seemingly important factor by itself. And, as an example of this fact it may be noted that the pumping engine in this country, if not in the world, which holds the high duty record has the following conditions to work under:

Capacity per 24 hours, 15,000,000 U. S. gallons.
Piston speed, 197 feet per minute.
Rotative speed, 20 revolutions per minute.
Water load against pumps, 126 lbs. pressure.
Steam pressure per gauge, 126 lbs. pressure.
Indicated power, 802 horse power.
Mechanical efficiency, 96 per cent.
Steam per hour I. H. P., 10.68 pounds.
Duty per 1,000 lbs. steam, 179,454,250 foot pounds.

Regarding high piston speed, the best record known to the writer as to pumping engines is 607 feet per minute, where the duty per 1,000 lbs. of steam was 157,843,000 foot pounds, showing that higher piston speed alone will not answer.

Regarding high steam pressure the record seems to be 200 lbs. and a duty of 149,500,000 foot pounds, showing that high steam pressure in the absence of other ruling conditions or proper fitness falls short of the best performance.

Regarding thermal efficiency, or the actual economy of heat employed with reference to absolute temperatures, even the greatest thermal efficiency does not in the presence of adverse conditions in some other direction, equal the engine working under the best general fitness of things as will be seen by the following:

Thermal efficiency.	Duty per 1,000 lbs. steam.
22.8 per cent.	149,500,000 foot pounds.
21.63 " "	178,497,000 " "
21. " "	179.454.250 " "
20.85 " "	173,620,000 " "
20.78 " "	176,419,600 " "

What is considered the record for general all round efficiency for a pumping engine up-to-date is as follows:

Capacity per 24 hours, 30,000,000 U. S. gallons.
Steam pressure gauge, 185 lbs. per square inch.
Piston speed, 195 feet per minute.
Duty per 1,000 lbs. steam, 178,497,000 foot pounds.
Duty per million heat units, 163,925,300 foot pounds.
Steam per hour, I. H. P., 10.335 pounds.
Thermal efficiency, 21.63 per cent.

With reference to the steam economy of the higher type of pumping engines and its repetition in different engines it may be noted that covering a period of more than three years, five pumping engines of a similar type, of different builders, and situated many miles apart, gave steam per indicated horse power ranging through the following figures:

10.33 pounds per indicated horse power per hour.
10.63 " " " "
10.78 " " " "
11.01 " " " "
11.10 " " " "

It hardly seems probable that materially higher efficiencies will be obtained in the near future at least, and not very much higher efficiency is posible with the steam pressures seemingly practicable to employ in pumping stations; super-heat in the steam will no doubt carry the record to slightly higher figures, perhaps to 200,000,000 of foot pounds or a trifle higher, as the reheating and superheating of the receiver steam by means of coils in the boiler connections or smoke flues will also tend in the same direction, but, of course, net gain is what is sought, and fancy duty figures at the expense of heat in some other part of the plant will not add to real economy in the long run. But, however, the steam or heat efficiency may be improved, or, however, many times the present record may be reached in the

future, the durability of the machinery for the purpose of its existence comes first and should not be sacrificed to any fancied betterment in steam economy only.

In preparing specifications and contracts for commercial pumping engines, it is generally thought best to set forth very plainly the requirements to be met, the guarantees expected, and the terms of payment proposed; stating the various conditions under which the water is to be pumped, the duty obtained, water pressure, steam pressure, piston speed, length of duty test, etc. Also stating penalty, bonus, or damages, and the utlimate action of the buyer to be expected in case the engine fails to meet the contract, or falls a certain amount short of the contract requirements.

The questions of what type of pumping engine is required needs careful consideration; horizontal, vertical, triple expansion, compound or double expansion, fly-wheel, direct action and all other matters and facts likely to have important bearing upon the subject should be taken into account in making a selection. In fact, the class or type of engine can be pretty thoroughly sifted down, and then the competition called for upon lines suited to the particular case in hand, and so avoid the complications and uncertainties resulting usually from a wide open specification.

Mr. Hague: The turbine pump and engine is now coming to the front, and is making rapid progress. The combined mechanical efficiency is between 68 and 70 per cent, which you see is a long ways below that of the reciprocating engine. The capital account is very much less as against the fuel account. The difference between 70 per cent., for example, and 96 per cent. efficiency in favor of the reciprocating engine, will pay ten or fifteen per cent. return on the entire cost of the displacement engine; and it would probably pay 25 to 30 per cent. upon the difference between the two kinds of plant.

If the efficiency of the turbine pump itself can be brought up to the proper point, and if the efficiency of the turbine steam engine can be brought down to the proper steam consumption, it will present a very attractive formation of pumping engine. Even if that is accomplished, however, there are other troubles in sight with regard to wear and tear. Very little grit in the water at these speeds would apparently make a very high repair bill in disturbing the internal arrangements of a turbine pump; but of course it is time enough to cross that bridge when you get to it. The first thing that the turbine pump has to do is to increase its efficiency to the point where it can hope to compete in the waterworks practice of to-day with reciprocating pumps.

President Sherrerd: I think that all of us must feel indebted to Mr. Hague for his excellent paper and for the time that he has evidently given to its preparation. The Secretary has some written discussion of the paper, which will be in order.

DISCUSSION.

Mr. Irving H. Reynolds: As a builder of the class of commercial pumping engines described by Mr. Hague, I appreciate very much the value of his paper, for he has presented all features of the case, and water works managers could not do better than to follow his suggestions in the purchase of pumping machinery.

Mr. Hague has fortunately been on both sides of the question—first as a seller of pumping machinery, and later as a buyer, and in consequence he understands fully the commercial limitations of the manufacturer, and also the points on which the purchaser requires protection.

Mr. Hague's remarks on "wide open" specifications, and the "grab bag" method of selecting machinery are very much to the point, and if purchasers of engines would keep in mind the old maxim, "Be sure you are right and then go ahead," they would save themselves and the manufacturers much trouble, and would also be insured of obtaining machinery properly adapted to their requirements. Restrictions as to the general type of engine, speed, stroke, etc., within reasonable limits, are entirely proper and should be incorporated in every specification.

The observations regarding the exclusion of foundations, buildings, etc., from the engine builder's contract show a thorough appreciation of the situation, and as Mr. Hague observes, the interest of the purchaser will be better served by making these items the subject of separate contracts.

The paper is of such general excellence that I have nothing really in the nature of criticism to offer, but would like to say a few words on some points discussed by Mr. Hague.

VALVE AREA.

There has been a growing tendency to overdo the matter of valve area, which naturally increased the cost of the pump and without benefit to the purchaser. In one recent instance 180 per cent. valve area was required for 180 feet plunger speed; being exactly double the amount recommended by Mr. Hague, and certainly largely in excess of any requirements of the engine.

The valve areas suggested by Mr. Hague are conservative and sufficient for long stroke medium speed pumping engines, although rather less than the writer is using in his present practice. Broadly speaking, the valve area is not necessarily proportional to the plunger, but rather to the quantity of water flowing through the pump, and for that reason I would suggest that it is better to state the *total* valve area required for a given quantity of water.

A very conservative rule, and one which can be easily remembered, is to require a total suction and a total discharge valve area of one square foot for each 1,000,000 gallons capacity. For instance, a 3,000,000 gallon engine would have 3 square feet of suction valve area and 3 square feet of discharge

valve area regardless of the number and size of plungers, and a 10,000,000 gallon engine would similarly have 10 square feet of valve area on both suction and discharge.

Of course when it gets down to the actual construction of the machine there are other points to be taken into account beside the question of plunger speed, for the number of strokes per minute, as well as the diameter of the pump valves, are important factors. For instance, with a given plunger speed per minute a short stroke, high revolution engine requires more valve area than a long stroke, slow revolution engine, as the time allowed for the seating of the valves is less in the high revolution engine, and consequently the valves can not be allowed to lift as high from their seats.

The lift of the valves brings up the question of their diameter, which also has a bearing on the total valve area to be provided. Valves of large diameter and high lift while satisfactory on slow revolution engines, would not answer at all on high revolution engines, and in general the use of large diameter valves is not to be recommended, and in the writer's practice valves larger than 4 inches diameter are seldom used and then only on slow revolution engines.

MATERIALS.

While Mr. Hague does not specifically recommend hollow forged shafts, etc., yet his remarks would indicate that he advocates their use, but as we are discussing "commercial" pumping engines I can not agree with him.

Hollow shafts are in general used and adapted for situations where lightness, combined with the maximum of strength, is required, such as on steamship shafts, engine shafts carrying very heavy wheels, electric generators, etc.

There are two methods of making hollow shafts, one being to forge them hollow on a mandrel, and the other to forge them solid and bore the center hole afterward.

There is but one forge in America, and but one or two in Europe, equipped to make hollow forgings by the first method, but there are many concerns furnishing hollow *bored* shafts. In pumping engine work, however, there is no necessity for keeping down the weight of parts, nor are the strains so ex-

cessive that they can not be safely carried with ordinary material, and as the hollow forgings mean considerable increase in the cost of machinery, their use is not warranted in what Mr. Hague describes as the "Commercial Pumping Engine."

Mild open hearth steel having a tensile strength of from 60,000 to 70,000 lbs., with an elastic limit of 50 per cent. of the tensile and an elongation of 25 per cent. to 30 per cent. in 2 inches is, in the writer's opinion, a material perfectly adapted for the general forgings used in the construction of a pumping engine.

STEEL CASTINGS.

The statement is made "that in the better practice forged steel crossheads are used where practicable or appropriate," which statement might be construed to mean that the use of cast steel in crossheads is not in accordance with the best practice.

In some of the earlier types of pumping engines the crossheads were very long and guided at both ends, and forged steel was the rational material for them, but in later designs of engines the use of frames having bored guides is common, and while the crossheads for these guides could be forged, yet they are of such peculiar shape that to do so would make them enormously expensive, and steel castings answer every purpose. The usual specifications for steel castings are 60,000 to 65,000 pounds tensile strength, 30,000 pounds elastic limit and 20% elongation in 2".

WROUGHT IRON.

Comparatively no wrought iron now enters into the construction of machinery, excepting for bolts, etc., and the specifications usually are for 45,000 pounds tensile strength, 25,000 pounds elastic limit, and 20% elongation in 8".

Mr. Hague's specification requiring 55,000 pounds tensile per square inch in wrought iron appears to be exceedingly high, as it is very difficult to get iron which will run uniformly above 50,000 pounds per square inch, and the requirements of the Bureau of Steam Engineering, U. S. Navy, are for only 48,000 lbs.

CAST IRON.

The castings are more likely to be slightly defective than any other portion of the work, and any interpretation of the specifications which insists on absolute perfection in castings is one which it is almost impossible for the manufacturer to fulfill, and which, if insisted upon, enormously increases the cost of machinery, as several manufacturers have learned to their great sorrow. The castings should be free from defects impairing their strength or seriously affecting their appearance, and inspectors, when employed, should have had sufficient experience to be able to distinguish between *practical* perfection and *absolute* perfection.

It is desirable to use more than one grade of cast iron in engine construction, and the cylinders, pump bodies and other parts subject to pressure are commonly made of iron having a tensile strength of 22,000 to 25,000 pounds, while the bedplates, frames, wheels, etc., can be made of cast iron having a tensile strength of from 18,000 to 20,000 pounds, the transverse breaking load in each case being practically 10% of the tensile, and the deflection being from .35 to .40, the size of the bar usually being 1 x 2″, supported 24″ c. to c.

The finish of engines is usually left very vague, some specifications requiring "all machine worked surfaces and all moving parts above the engine room floor, excepting the fly wheels," to be finished and polished.

This requirement is seldom, if ever, carried out, and would be exceedingly expensive, and as we are dealing with "Commercial Pumping Engines," I would suggest that if the specications required the shafts, connecting rods, valve links and rods, exposed composition work, and in general all *machine-worked* moving parts to be polished, the result would be in accordance with usual practice and supply all the finish necessary to give the machinery proper appearance.

Another item of expense is in the use of case hardened and finished nuts, it being common practice to specify, as Mr. Hague has done, that such nuts shall be used on all exposed work above the operating floor, and also on parts requiring frequent removal or adjustment.

Case hardened nuts, particularly in the larger sizes, are enormously expensive, and their use may very well be restricted to parts requiring frequent removal or adjustment, as the ordinary pressed nut is entirely suitable for permanent joints, frame and foundation bolts, etc., whether visible or not.

As a broad proposition, pumping engine builders have every incentive to use good material and supply good workmanship. The first because under the usual guarantee of maintenance for one year the engine builder is responsible for all breakages due to defective material, often covering a period of two years from date the engine is first put into operation, and therefore would not put into the machinery any material which was obviously defective, and therefore likely to fail in service, and he is impelled to good workmanship for the reason that the high duties now demanded necessitate not only good design but the best possible workmanship in order to meet the requirements of economy.

In fact, if there is any class of machinery which is built "on honor" it is the high duty pumping engine as constructed by experienced manufacturers.

Mr. Alvord: Those of us who have known and looked up to Mr. Hague for the past twenty-five years cannot but feel that anything that he may say upon the subject of pumping engines should be regarded very seriously indeed and as having great authority. I think, however, that in one respect possibly a misconception may arise which Mr. Hague did not himself intend, in speaking of rotating machinery.

Mr. Hague has evidently been speaking to us of engines of the very highest class, and of the very largest class, engines capable of lifting large quantities of water in our most important pumping stations. Now the majority of us have to deal with pumping engines much lower in capacity and efficiency than those which Mr. Hague has been discussing, and it is becoming of great interest in connection with these smaller plants as to where the line should be drawn in considering rotating machinery, for the efficiencies of rotating machinery are already so high that I believe we may properly consider them in competition with these less efficient classes of engines. Then, too, it may be said for rotative machinery that there are

many situations where it has a peculiar adaptability, such as the ordinary vertical shaft rotating machinery in deep pits, and rotating machinery in peculiarly exposed positions—exposed to flood perhaps; so that this type of machinery I am sure possesses some merits which Mr. Hague I think would be perfectly willing to admit are already before us for serious consideration.

Fortunately we have another paper upon this subject, which will no doubt be of interest to you all in this connection; but I myself am free to say that I am somewhat disposed to view rotative machinery as having a very interesting future in the next few years, and I am free to say that I believe it is going to be adopted in the very near future in a great many especial situations. I have two important installations under way in which I think rotative machinery shows marked advantages over any class of pumps of the commercial type, such as are described by Mr. Hague. Therefore, with all due deference to what Mr. Hague has said as to this high type class, which we must admit is very true, let us not overlook the distinctive field which rotative machinery is now entering on—and I may say has already entered, with success.

Mr. Maury: Without revealing too much of the secrets of the star chamber proceedings of the Publication Committee, I think I may safely say that there was a unanimous consensus of opinion that the Society was very much to be congratulated on receiving from Mr. Hague this most able paper which we have all enjoyed hearing.

He spoke of recent practice in polishing the inner surfaces of cylinders and the flat surfaces of pistons, with a view to checking radiation. Not very long ago I was in conversation with one of the most prominent marine engineers in the country, and he told me that it was the practice of the man who builds the fast steam yachts and who built the yacht said to be the fastest in the world, Flint's Arrow, to set up his marine engine in the shop, polish all working surfaces on the valves, cylinders and pistons, and then fill the cylinder and all the working parts of the valve that were accessible with graphite, and run the machine with a belt until the graphite was thoroughly buffed into all the working surfaces. This was not for any reason of thermal economy, but it was to attempt to solve

the feed-water problem aboard ship. Then, according to my informant, this builder was bold enough to set up his marine engine, sometimes a triple expansion engine, aboard his boats without an oil cup for the lubrication of either valve or piston and send the boat to sea. That is carrying the principle of polishing the cylinder a step or two further, but of course for a different reason.

In regard to what Mr. Hague said in his closing impromptu remarks with reference to turbine pumps, and Mr. Alvord's interesting discussion, I shall of course have a word to say later, because I have a paper on that subject. I do not think that when it is reduced to its last element there will really be any great difference either between Mr. Alvord, Mr. Hague or myself; because the points which will decide whether a reciprocating engine or a turbine pump shall be used will be such that they will result in placing those two machines in different fields entirely. Each has its field of usefulness. No one, I think, can claim for either that it will always be the engine that will be adopted everywhere. They will be, in situations that are close to the dividing line, in a certain sense competitors, but there will be large areas of that field, so to speak, in which each will unquestionably, I think, stand supreme until something else—possibly not the steam engine—comes up.

Mr. Maignen: I would like to ask the author of this most complete paper the simple question of what is the best device to prevent an engine running away when the pump wells get dry?

Mr. Hague: I think the best device is a well posted attentive engineer, but from a mechanical standpoint the best device would be a vacuum breaker on the condenser, so arranged that when the water falls to a dangerous point in the well, the vacuum would drop to zero and stop the engine.

While I am on this subject I would like to make a remark in reply to Mr. Reynolds' discussion. Mr. Reynolds speaks of the question of hollow steel shafts. I do not know as I have advocated them very specifically; but what I have said in that direction is more for the purpose of getting a good sound forging rather than in reducing the weight. There is no

particular object in reducing the weight in a pumping engine, because water being such a rigid material to handle, a large counter-mass is to be desired in the machine; and in handling water, as you water people all know pretty well, you often get into trouble from the very rigid and obstinate nature of the material you are handling; and with a pumping engine with its pumps filling and discharging a good many times in an hour, there is a certain shock which is not found in an engine driving a factory, or in an engine driving a dynamo, and because of the strain put at high pressure on the cranks and flywheel shafts, a high type of material is to be desired in crank-shafts and piston-rods, and the matter of whether there is one concern in America or in Europe that makes them is something that I do not bother much about. As a matter of fact, there are two concerns, at least, in this country, the Bethlehem and Midvale Companies, both making hollow forgings, the only difference being in the kind of steel used. I do not suppose there is much difference. In fact, the test I apply is what I give in the paper; and if these points are systematically met, the shafts, connecting rods, piston rods and cranks will be perfectly safe if made from the ingots from which the test coupons are taken.

He also speaks of the matter of cast iron. I agree with him very thoroughly on the point about impractical exactness in checking up castings. There are very many large and valuable castings that might have a slight blemish, which you could not even call a defect sometimes; and in my opinion the engineer should have courage enough to make up his mind whether that casting will answer practically or not; and if it will, I think the engineer ought to be fair enough to give the manufacturer the benefit of it. I have condemned castings weighing as much as eight tons because I thought some parts were so defective they could not be remedied. I have passed castings where there were blemishes that could be removed at very small expense, that added nothing whatever to the risk, in fact the casting practically was just as good as though the blemish did not exist. I think that is a point where the engineer ought to have enough courage to use his own judgment and then act upon it.

Mr. Boardman: I hate to get on my feet again, but I do not like one suggestion of Mr. Hague's to pass unchallenged, and that is his reference to the wear and tear upon a turbine or centrifugal pump in the use of gritty water. I am inclined to think that it is less than in the reciprocating engine. I wanted to make that remark so that it might be further brought out in the discussion of Mr. Maury's paper.

Mr. Hague: In reply to that I would simply say that there is not enough known about the subject as to what gritty water will do in turbine pumps. There are none of them in use in a practical manner in waterworks. I wrote a contract myself about a year and a half ago for two 12,000,000 gallon pumps, and after struggling with the single type for six months, the double type was adopted, and that plant is not yet running in a manner that the waterworks people can tell anything about it at all. There is some slight indication that there is a scouring effect. Whether that is going to amount to anything in the course of a few years can only be told at the time when the turbine engine becomes a commercial engine.

Mr. Maury: So far as scouring is concerned, there is no question of the fact that turbine or centrifugal pumps are better able to stand it than reciprocating pumps.

Mr. Boardman: My reason, Mr. President, for bringing out the point was suggested by the fact that in dredging, centrifugal pumps are generally used, and the wear and tear caused by the sand being pumped up through the dredge has not been found to be excessive, or to necessitate expensive repairs; and they are used in situations where reciprocal pumps cannot be well used.

Mr. Maury: I think if an attempt were made to use a reciprocating pump as a dredging pump, it would soon go out of business on account of the sand alone if for no other reason.

Mr. Alvord: I might mention also that the best forms of centrifugal pumps are the balanced pumps in which there is no thrust to be taken care of; consequently the friction is very much diminished. In certain forms of vertical pumps they are so automatically balanced that there is no down thrust on the shaft in carrying the load, and the thrust is actually floated in the water. The importance of this must be seen to be very great

in considering the question of friction in rotating machinery, and there can be no doubt in my mind that with a properly designed pump of the highest class of rotative machinery, with these improvements, they are able to handle gritty water with much more ease and much less wear and tear than will reciprocating machinery.

AN ADDITIONAL SUPPLY OF WATER FOR THE CITY OF NEW YORK.

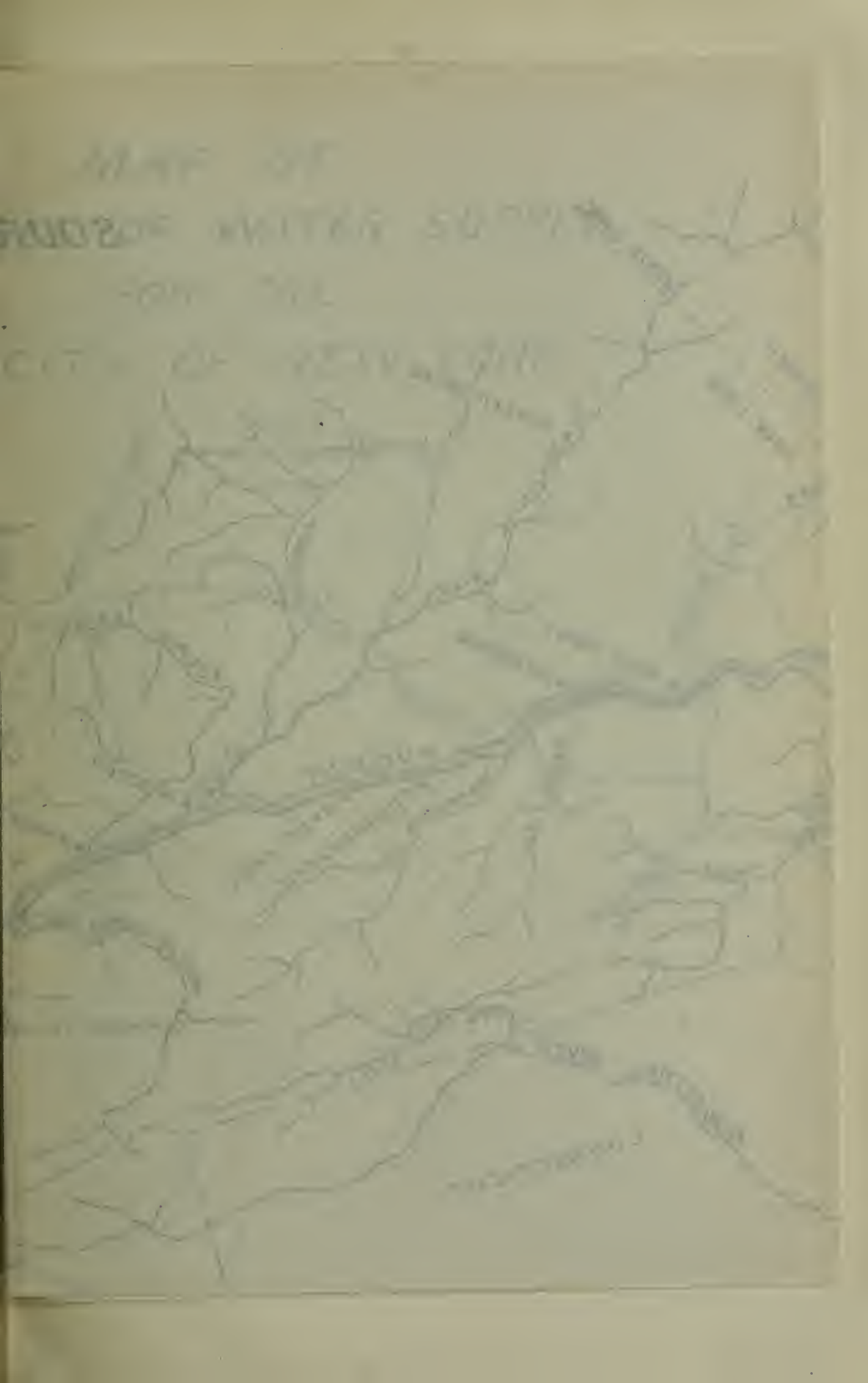
By William R. Hill.

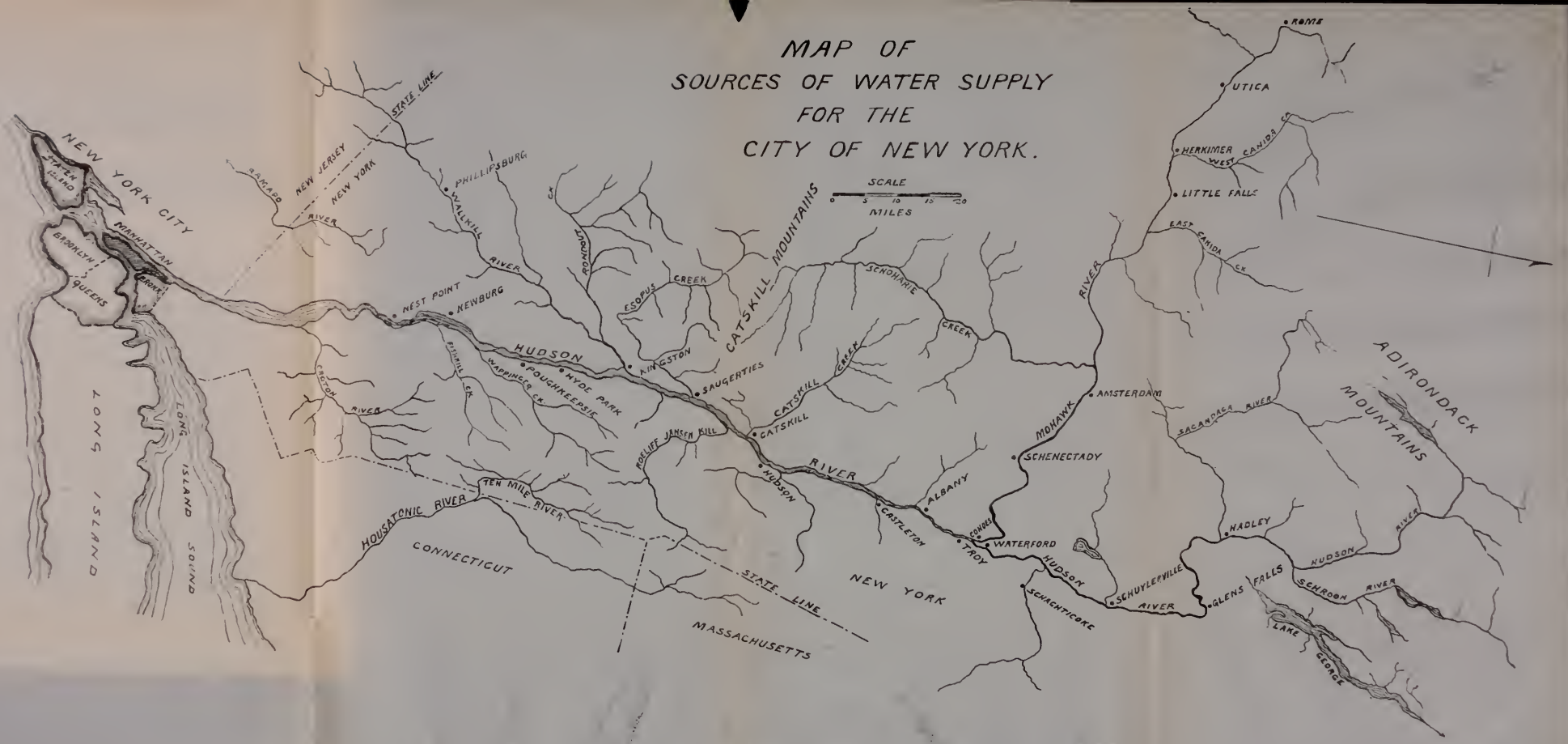
The City of New York is urgently in need of an additional supply of water for domestic, mercantile and municipal uses; in fact, an absolute shortage was only averted in the past four years by the uncommonly heavy rains. In pursuance of the above statement, it might be well to state that the average rainfall in the preceding thirty years was 48.7 inches per annum, while the average of the past four years reached 57.9 inches, showing an increase of nineteen per cent. over that of the preceding thirty years.

So close is the quantity of water consumed to the normal yield of the waterworks, that a period of three years of light rainfall could not elapse without resulting in great hardships; and it is questionable as to whether there would be a sufficient supply of water even in one year of light rainfall. This condition is rendered still more perilous because of the additional demands for water, due to the rapid increase of the population and industries of the city.

It is almost impossible to conceive the distress which would suddenly befall the city, owing to a dearth of a supply of water. It would cause stagnation in all manufacturing and business interests to an extent, which we are incapable of anticipating. It would expose the city to danger of most disastrous destruction by fire and otherwise cause inconvenience, distress, sickness and death to many people. On the other hand, an adequate supply of pure and wholesome water is imperative to the health, happiness and prosperity of any community. It constitutes the greater portion of our food and contributes to our comforts and pleasures; in fact, every essential of life is absolutely dependent upon it. Therefore it is imperative that steps should be immediately taken to secure an additional supply of water. And in selecting the source of supply, it is paramount to all other considerations that the quality of the water should be the best obtainable.

Although the necessity of an increased supply has been repeatedly presented to the people, it is evident that a large





Proceedings American Water Works Association, 1905.

majority of them do not comprehend the impending danger that so seriously threatens their welfare.

Several investigations and reports have been made relative to various possible sources of supply, and the most thorough is that of the "Commission on Additional Water Supply," consisting of Messrs. Wm. H. Burr, Rudolph Hering and John R. Freeman.

This paper is the result of a study of several reports and is conclusions resultant from the analysis of samples of water, as well as a cursory examination of the physical conditions of several suggested sources of supply, briefly reviewing their important features.

ESOPUS CREEK.

Esopus Creek rises in the Catskill Mountains, in Ulster County, and flows easterly into the Hudson River at Saugerties.

It is the best source of supply available for the city. The water is of excellent quality, being to a remarkable degree free from organic impurities, and, in every respect, superior to Croton water, the present supply for the Boroughs of Manhattan and Bronx. It is tasteless, odorless, and almost colorless. In fact, so slight is the color, that it would not be noticeable in a porcelain bathtub. In this respect, as well as in many others, it is preferable to the well known sparkling water of Lake George. It contains but a very small quantity of albuminoid ammonia, which is one of the most dangerous substances that chemists generally find in water, there being present but 28 per cent. of the amount found in Croton water; and a further comparison with Croton water shows it to contain but 38 per cent. as much free ammonia, 50 per cent. of the nitrites and nitrates, 45 per cent. of the total solids, 29 per cent. of the chlorine, 32 per cent. of the alkalinity, 22 per cent. of the iron, 38 per cent. of the hardness, and a microscopical examination disclosed but 50 organisms existing in a cubic centimeter of Esopus water, as against 675 found in an equal quantity of Croton water. Hence, the water of Esopus Creek answers favorably every practical demand, being very pleasant and

healthful for domestic use, as well as most desirable for laundry and steam purposes.

There is an excellent site for a reservoir at Olive Bridge, about 13 miles westerly from Kingston. A reservoir at this point, with a flow line 560 feet above tide level, would have a capacity of one hundred thousand million gallons, which would be greater than the capacity of any reservoir heretofore built for municipal supply. A very great safeguard to the healthfulness of the water will be found in the great size of the proposed reservoir, as the long time required for the passage of water through it would have a most important influence on sedimentation and sterilization, as most of the pathogenic bacteria will die in from two to four weeks, and another benefit will be that the water in a large reservoir will be less affected by organic growths.

The water shed above Olive Bridge is free from swamps and lime stone, hence the water is practically free from color and hardness. The area includes steep mountain slopes, 90 percent. of which is covered with forest growth. It is sparsely settled, the permanent population being only about 20 inhabitants to the square mile, but this, however, is increased to about 31 during the summer. The population is confined chiefly to villages, the drainage from which could be treated and made unobjectionable from a sanitary standpoint. The vast forest area, a wilderness (so to speak), uncultivated and practically uninhabited, is an ideal water shed in its freedom from artificial impurities. The available water shed covers an area of about 255 square miles, which is estimated to yield about two hundred and fifty million gallons of water daily.

An aqueduct about 81 miles long would be required to convey the water to a high service reservoir, which should be built adjacent to the city, with the water surface about 295 feet above mean high tide level, or 180 feet higher than the distributing reservoirs in Central Park. This high elevation would afford better pressure where applied to the distributing system, and would obviate the necessity of pumping water as is now being done to supply the higher parts of the city.

RONDOUT CREEK.

Rondout Creek also rises in Ulster County, flows northeasterly, and joins the Wallkill River about ten miles from its junction with the Hudson River at Kingston. The water is of excellent quality, and, in some important respects, is better than the water of Lake George, and is very desirable for domestic, laundry, steam, and general purposes.

That part of the water shed which is available for high service by gravity, lies southerly and adjacent to the Esopus Creek water shed. It covers an area of about 131 square miles, and is estimated to yield about one hundred million gallons of water per day. It abounds with hills, about 90 per cent. of which are covered with forest growth. It is sparsely settled, the population being about 35 per square mile. Rondout Creek would be a valuable adjunct to Esopus Creek, for, by a short aqueduct, the water could be conducted into an aqueduct connecting Esopus Creek with the city.

CATSKILL CREEK.

Catskill Creek rises in Schoharie County and flows southeasterly into the Hudson River at Catskill village. The water is of good quality organically, but not as pure as the waters of Esopus and Rondout Creeks. Still, it is better than Croton water, which it equals in softness.

That part of the water shed which is available for high service by gravity, covers an area of about 163 square miles, and is estimated to yield about one hundred and twenty-five million gallons of water per day. The country is hilly, and the slopes are steep. The permanent population is about 25 per square mile, increasing to about 33 during the summer.

SCHOHARIE CREEK.

Schoharie Creek rises on the northwestern slope of the Catskill Mountains, north of Esopus Creek water shed, and flows northerly into the Mohawk River. The water is of good quality, still it is higher in albuminoid ammonia than the water of Esopus, Rondout, or Catskill Creeks. It is softer than any other water available, having but 8 degrees of hardness, while Croton show 39.4 parts per million.

That part of the water shed which is available for high service by gravity, covers an area of about 228 square miles, which is estimated to yield about one hundred and seventy-five million gallons of water per day.

The permanent population is about 28 per square mile, but this is more than doubled during the summer. Although Schoharie Creek lies on the northwesterly side of the mountains, it would be feasible to divert its water into the Esopus Valley, by means of a tunnel about ten miles long.

LAKE GEORGE.

The water of Lake George is of excellent quality for municipal supply. The elevation of the lake, however, is only 323 feet above sea level, which is not sufficient without pumping to permit of the water being delivered to the city at the required height.

The water shed of the lake has an area covering about 230 square miles, which is estimated to yield about 200 million gallons of water daily; this quantity is not sufficient to justify the great expense of constructing an aqueduct about 180 miles long and of pumping the water to the required height.

TRIBUTARIES OF THE HUDSON RIVER.

An ample supply of water could be obtained from the upper tributaries of the Hudson River in the Adirondack Mountains. These waters are generally colored higher than is approved, and have a disagreeable vegetable taste and odor, due to the presence of organic matter in tamarac swamps.

The water is soft and is safe organically, but not as pure as the waters of Catskill Mountain streams, or of Lake George. An aqueduct about 200 miles long would be required to convey this water to the city. The great cost to construct this long aqueduct would also contribute to make this source of supply prohibitive.

HUDSON RIVER AT HYDE PARK.

The water of Hudson River at Hyde Park should be regarded with suspicion, as it receives one of the worst forms of pollution, viz., the sewage of several cities and villages, the quantity of sewage increasing with increasing population.

There is also a possibility of infection by salt water, due to the rising tide. To overcome such a contingency, large storage reservoirs would be required in the Adirondack Mountains to impound flood waters to be discharged into the river during dry periods to prevent the upflow of salt water, a small amount of salt seriously affecting the value of the water for steam and industrial purposes.

By such regulation of the flow of the river and by proper filtration, the water in no worse condition than at present, could be made safe for municipal supply. It is not expected, however, even after the most approved treatment, that the water would be of as good quality as that of the Catskill Mountain streams without any treatment.

Besides the great expense of constructing large storage reservoirs in the Adirondack Mountains, and of constructing and operating a filter plant, it would be necessary to pump the water to an elevation of about 400 feet. An aqueduct about 67 miles in length would be required.

FISHKILL CREEK.

Fishkill Creek rises in Dutchess County and flows southeasterly into the Hudson River at Fishkill Village. The water is of good quality organically, but as the main stream flows for nearly its entire length through an area of lime stone, the water is so hard that it would be undesirable, unless it was diluted with a soft water. It is more than twice as hard as Croton water, and yet the latter, although generally considered a soft water, closely approaches the limit above which it would be necessary to use chemicals with the water in boilers.

A hard water in the laundry wastes soap, and compels the use of soda or other chemicals, which are injurious to fabrics. When used for the bath, it forms an unsightly curdle with soap and affects the skin unpleasantly. It is very objectionable for steam purposes, as it wastes coal, compels the use of chemicals, produces scale in boilers, lessens their efficiency and shortens their life. It is also objectionable in many industries, especially when used in connection with chemicals.

The water shed lies northerly and adjacent to that of Croton River. About 80 square miles could be made available, which

is estimated to yield about sixty million gallons of water per day. It could be conducted into the Croton Valley by means of an aqueduct, 21 miles long.

By Chapter 752, of the laws of 1904, the city is deprived of power to acquire, by condemnation, any rigths in this creek or water shed, hence, this source of supply is rendered impracticable.

WAPPINGER CREEK.

Wappinger Creek rises in Dutchess County and flows southwesterly into the Hudson River about ten miles below Poughkeepsie. The water is noticeably colored and contains organic matter to a high degree, yet it is reasonably safe for domestic purposes. It is 38 per cent. harder than Croton water, and it is quite probable that it would be necessary to use chemicals with it in steam boilers.

That part of the water shed which could be made available for high service by gravity, lies northerly and adjacent to Fishkill Creek water shed. It covers an area of about 90 square miles, and is estimated to yield about sixty-seven million gallons of water per day. It could be diverted into Fishkill Creek by an aqueduct 3½ miles long. By the laws of 1904, before referred to, this source of supply is also rendered impracticable.

ROELIFF JANSEN KILL.

Roeliff Jansen Kill rises in Berkshire County, Mass., and flows southerly, and then northerly, into the Hudson River at a point nearly opposite Catskill Village.

The water is fully three times as hard as Croton water; hence, it would be undesirable, unless it was diluted with a soft water. The commercial value of soft water over hard water is apparent from the fact that in using hard water, boiler compounds are required, and a greater quantity of soap is necessary. It is estimated that in using two hundred and seventy-five million gallons daily of the soft waters of Esopus and Rondout Creeks, instead of the hard waters of Fishkill and Wappinger Creeks and Roeliff Jansen Kill, that the saving in boiler compounds and soap would amount to the large sum

of about $700,000 per annum. In considering the above, the other very important objections to hard water, heretofore mentioned, must be regarded as well.

The water shed available for high service by gravity, covers an area of about 150 square miles, of which about 7 miles are in the State of Massachusetts. It is estimated to yield about one hundred and twenty million gallons of water per day, which could be diverted into Wappinger Creek by an aqueduct 7½ miles in length. By the laws of 1904, before referred to, this source of supply is also rendered impracticable.

TEN-MILE RIVER.

Ten-Mile River embraces waters rising partly in New York and partly in Connecticut, flowing through New York to Connecticut and into the Housatonic River. The water is of good quality organically, but it is so hard that it would be undesirable for municipal supply.

It is contended that the city has no right to divert the flow of this river from the State of Connecticut, for in case of such diversion, a riparian owner on the river in Connecticut could enjoin the proposed diversion; hence, this source of supply is surrounded with legal difficulties, which render it also impracticable.

WALLKILL RIVER.

Wallkill River rises in New Jersey and flows northerly through the State of New York into the Hudson River near Kingston. A dam on the river at Phillipsburg, about 60 feet high, would form a reservoir that would flood an area of about 50 square miles of drained swamp lands, commonly known as "Drowned Land." Until about sixty years ago, this area was covered with several feet of water, held by a dam of glacial drift. A canal cut through this dam has drained the land and rendered it fit for cultivation. Peat and muck deposits over the entire area have a depth varying from 5 to 50 feet. It is a black, highly carbonaceous soil, of from 70 to 95 per cent. organic matter. Water standing in contact with this would soon acquire a dark brown color, a distinct odor, and an unpleasant taste. The water is hard, and would probably require the use of chemicals for steam purposes.

About one-fifth of the area of the reservoir would be in the State of New Jersey, which land the city could not obtain by condemnation, and could only acquire by purchase. The water shed above Phillipsburg covers an area of about 465 square miles, of which about 190 square miles is also in the State of New Jersey.

The city would have no power of preserving the water or the drainage area from pollution in New Jersey, except by purchase. This would be a most annoying condition, as many unscrupulous persons might purposely pollute the water in order to secure a settlement from the city.

RAMAPO RIVER.

The water of Ramapo River is of good quality for municipal supply. The river rises in the State of New York and flows into the State of New Jersey; hence, this source of supply, like the Ten-Mile River, is surrounded with legal difficulties, and thus rendered impracticable.

SUMMARY.

To present briefly, the waters of Esopus and Rondout Creeks are of excellent quality; the waters of Catskill and Schoharie Creeks are of very good quality, and all these are available by gravity. The water of Lake George is also of excellent quality, but the yield is too small to justify incurring the great expense necessary for the construction of so long an aqueduct and for pumping the water to the required height. The water of the tributaries of the Hudson River in the Adirondack Mountains is undesirable, as it is high in color, and has a disagreeable taste and odor. The water of the Hudson River at Hyde Park is objectionable, as the pollution would make filtration necessary, the salt caused by the tide would require the regulation of the flow of the river and the low level would call for high pumping.

The above seven are the only additional sources of supply, earnestly advocated, that are now available, as Fishkill and Wappinger Creeks, Roeliff Jansen Kill, Ten-Mile, Wallkill and Ramapo Rivers are unavailable on account of legal difficulties.

CONCLUSIONS.

Of all the above named sources of supply, the waters of two, Esopus and Rondout creeks, conform most closely to the requisites of an ideal water supply, the quality of which would be second to that of no other large city in the world. The natural conditions are such, that large storage reservoirs can be constructed in the valleys of the creeks, and these at such an elevation as to permit a gravity high pressure system to be established in the city. With the acquisition of such a supply and system, the city would be blessed beyond measure.

The Commission on Additional Water Supply has recommended these waters as the best source of supply, and in their report advocate that the aqueduct leading to the city should be of a capacity of at least four hundred million gallons per day.

Unfortunately, the city is in grave danger of a deficiency even before the construction necessary for an additional supply from these sources can be completed, as this would require a period of from five to eight years. In this contingency, the commission before mentioned, has recommended the immediate construction of two additional storage reservoirs in the Croton River watershed, but, even with this accession, without plentiful rains, there would still be danger of a deficiency.

METERS.

The necessity of installing meters to prevent waste and unnecessary use of water, should receive serious consideration. The great advantages resulting from their use are no longer questions of doubt, as the consumption of water per capita invariably decreases as meters are installed. The pursuance of this, is the following forcible illustration. In one hundred cities in the United States, having an aggregate population of eleven million in the year 1901, the average consumption of water per day was one billion, four hundred and fifty-seven million gallons, which was equivalent to 132½ gallons per capita per day. In these cities there were then 1,531,000 service pipes and 283,000 meters in use: hence, 18½ per cent. of the service was metered. The effect of the use of meters on the consumption of water in these cities is found by dividing the cities into five classes. In forty-one cities having less than 10

per cent. of their service metered, the aggregate of the entire consumption averaged 162 gallons per capita per day. In twenty cities having from 10 to 30 per cent. of the service metered, it averaged 127 gallons. In eighteen cities having from 30 to 50 per cent. of the service metered, it averaged 96 gallons. In nine cities having from 50 to 75 per cent. of the service metered, it averaged 75 gallons, and in twelve cities having from 75 to 100 per cent. of the service metered, it averaged but 58 gallons.

Thus the saving is most practically illustrated in the above, by showing the decrease from 162 gallons consumption per capita per day in 41 cities having less than ten per cent. of the service metered, down to 58 gallons consumption per capita per day in 12 cities having from 75 to 100 per cent. of the service metered, and this latter quantity of water abundantly supplying all the required purposes. So the effect of the use of meters is plainly seen, to greatly reduce the waste and unnecessary use of water, resulting in another great advantage, that is increasing the pressure on the distributing system, a most important factor in the protection against fire.

It might be interesting to note that about one-half of the supply of water for the Boroughs of Brooklyn and Queens is derived from wells. There is no doubt that the quantity so obtained could be increased, but its extent can only be determined by further development. However, it is practicable to supply these Boroughs from Esopus and Rondout Creeks.

Thus I have endeavored to show the merits of these several available sources of supply and feel that the city is to be congratulated, that nature has made possible so satisfactory a solution of this great problem.

CHEMICAL AND MICROSCOPICAL ANALYSES OF SAMPLES OF WATER COLLECTED DURING 1903.

	Parts per million.										
	Color.	Albuminoid Ammonia.	Free Ammonia.	Nitrites.	Nitrates.	Total solids.	Chlorine.	Hardness.	Alkalinity.	Iron.	Microscopic organisms.
Croton lake	27	.191	.077	.002	.10	71.0	1.7	39.4	31.0	.23	675
Esopus creek	8	.053	.029	.001	.05	32.0	0.5	15.0	10.0	.05	50
Rondout creek	11	.081	.035	.001	.03	22.0	1.2	11.0	8.0	.05	40
Catskill creek	9	.096	.047	.003	.05	63.0	0.8	39.5	33.5	.05	55
Schoharie creek	18	.120	.040	.001	.15	42.0	0.6	8.0	6.0	.40	230
Lake George	9	.092	.008	.001	.00	50.0	0.6	30.0	26.0	.20	110
Tributaries of Hudson river	33	.125	.027	.001	.15	37.4	0.6	18.2	11.5	14	41
Hudson river at Hyde Park	29	.143	.029	.009	.12	108.8	1.4	45.7	42.3	.46	135
Fishkill creek	23	.124	.096	.006	.20	130.0	1.2	94.0	60.0	.20	..
Wappinger creek	30	.188	.076	.002	.15	101.0	0.8	54.5	54.0	.20	105
Roeliff Jansen Kill	16	.116	.044	.004	.10	144.0	2.0	123.0	110.0	10	..
Ten Mile river	23	.140	.054	.006	.40	172.0	1.6	106.0	51.0	.70	..
Wallkill river	30	.160	.022	.002	.15	97.0	2.6	48.5	46.0	.20	95
Ramapo river	28	.078	.056	.004	.10	56.0	1.2	30.0	14.0	.10	68

Vice-President Rowe: Gentlemen, you have listened to a very valuable paper by Mr. Hill. We all realize how difficult it is to grasp the magnitude of those figures. Mr. Hill has evidently given a great deal of thought to this paper, which has certainly taken some time to get into such excellent shape and in such a way as to make us understand the situation thoroughly, although we are removed from the conditions surrounding the water supply of New York City. We certainly appreciate Mr. Hill's efforts in this respect.

DISCUSSION.

Mr. Rosamond: The paper just read is a most interesting one, as it discusses the future water supply of one of the greatest cities in America. It shows that the writer of the paper has given a great deal of care and painstaking study to the future water supply of New York City, and this Association will watch with interest the development of the water supply.

Dr. Mason: On page 4 of the paper Mr. Hill refers to the hardness of Croton water as being 39.4 degrees. He doubtless meant 39.4 parts per million. The hardness, if stated in degrees, would be one part of lime for fifty-eight thousand odd parts of water.

I should like to say a word about the reservoir referred to on page 3 of his paper. That is a very large water storage, and I should like to ask if it is contemplated to strip that reservoir. The remark is made that in a large reservoir there will be much less chance for the water being affected by organic growths. It is, however, always to be remembered that an irregularly shaped reservoir, be it large or small, has bays of greater or less depth surrounding the same, and we all know that a very considerable amount of organic growth will take place in shallow flowage in those bays, and a fair opportunity will always exist for the contamination of the main supply from the contaminated bay. I should like to ask Mr. Hill about that, and as to whether it is to be stripped or not.

With reference to the table, on page 10 of the paper, a comparison is there made as between sundry waters. I would ask whether those water samples were taken at corresponding periods of the year? What do these numbers represent? Are

they specific analyses, or are they averages? If they be specific analyses, then if one be taken during the floods of spring and another during the latter portion of summer, of course it would be a difficult thing for us to compare them.

With reference to comparing the sundry waters as per last column, "Microscopic Organisms," you will note that Croton Lake is high and that Catskill Creek is much lower.

There is no statement there as to the presence or absence of the bacillus coli communis. So far as the total count is concerned, I have never taken very much stock in that, except for the purpose of filter testing. I can refer you to many an analysis which will show a high count and yet the water be entirely reliable, and to many another showing a low count and the water be absolutely non-potable. It seems to me that they could have very greatly improved that table had another column been added showing a little more about the presence or absence of the so-called intestinal organisms; not but that we all know the bacillus coli communis is pretty generally distributed. At the same time, if it be persistently present in large numbers, it is a good thing to know that fact.

With reference to Catskill Creek, about which something has been said tending towards making it a pretty good water supply, I do not know just exactly what portion of that creek is to be tapped, but there is one thing very sure, if it be the low portion of the creek, there is a pretty liberal chance for pollution to enter. I know a great deal about that section of the country, having spent my summers there for a great many years, and I know that a populous portion of the west bank is drained by Catskill Creek. I should like to know just where the creek is to be tapped with reference to the town of Cairo, a little country village which is very largely increased in population during the summer, for surely there is opportunity for contamination there. Doubtless Mr. Hill will enlighten us on those points.

Mr. Hill: The degree of hardness is an error. It should be 39.4 parts to a million. The plans of the reservoir have not been prepared. It will, perhaps, be necessary to strip the area on account of decayed vegetable matter that naturally exists in forests.

In the Croton River water shed, the soil is composed mostly of sand and gravel, and there is very little vegetation. Here the ground was not stripped for any of the reservoirs. With reference to the Catskill Creek, I couldn't say just where that dam is located, I do not know just how it lies with reference to the village that you speak of.

Mr. Baker: If I remember rightly, the proposition of the Commission on Water Supply is to filter all of this water anyway. That may have some bearing on some of the questions that have been raised.

Two bills, I believe, were passed by the recently adjourned legislature. Perhaps the author of the paper would outline in brief the purport of those bills.

Mr. Hill: The Legislature has just passed an Act authorizing the city to construct waterworks to supply waters from Esopus and Rondout Creeks; but the bill has yet to be submitted to the mayor of the city, who is heartily in favor of the project, and has been promoting the matter during his entire term. And after his approval, the bill goes to the Governor for his approval, undoubtedly the construction of those works will be very quickly commenced.

Mr. Cole: The words which we have just heard give us timely warning, and emphasize the grave danger of water famine confronting the largest city of our country.

Meters have been suggested as the remedy for New York City to apply; opening up a large subject which I cannot fully discuss here.

In our largest cities there is strong opposition to the introduction of the universal system of meters, and in my opinion good reasons may be given for the growing belief that meters alone will not cure the evil of waste.

Much valuable data is being accumulated by water works engineers, showing that all the water is not "accounted for" even in cities where the universal meter system has been adopted. The discrepancy in total meter registration is sometimes as large as 25% to 35% of total supply. This loss cannot always be attributed to "slip" of pumping engines, although it has been an important factor in many places. It must be largely due to street losses. The ordinary house meter set at

the curb, or within the cellar wall cannot measure leakage of mains and service pipes.

The valuable measurements recorded for a number of towns in the Metropolitan District of Boston should be carefully studied in this connection. Reports for Providence, R. I., Worcester, Mass., Yonkers, N. Y., and other fully metered cities might also be quoted.

A very valuable report made by Mr. John R. Freeman, C. E., some years ago, showed the effect of the introduction of meters upon per capita consumption in the leading cities of the United States. Mr. Freeman's interesting "curve" of per capita consumption falls rapidly with the introduction of meters upon the first 10% or 20% of services which naturally include the large consumers. The curve falls much less rapidly until 50% of the services are metered. At about this point the general tendency is to show very little decrease in per capita consumption as more meters are added. Since Mr. Freeman's first chart was plotted in about 1899, much additional data has been collected, including more accurate figures for population based upon the 1900 census returns. A similar chart was prepared by the recent Commission of Engineers for the City of Pittsburg, Pa., revising and bringing the work down to date. Practically no change in the general location of the curve has resulted from this revision.

The best engineering evidence that we have today seem to show that in the United States very little is accomplishd in the reduction of per capita consumption by metering more than 40% or 50% of all consumers, beginning with the largest.

To further illustrate my point, I would refer to an interesting district test which I made during the recent water waste investigation in New York City with the "Pitometer" under the direction of Mr. N. S. Hill, Jr., then Chief Engineer of the Water Department.

This was our district No. 8, as described in a paper read before you a year ago; comprising all of Manhattan Island south of Fulton Street. Here is a typical business section, where by law every building should have a meter. Out of a total measured supply of about 9,000,000 gallons daily to this district, 4,000,000 *or* 45% *was unaccounted for by its meters.* In

my opinion the largest part of this startling discrepancy was due to illegal use of water through unmetered connections or bye-passes, although it is not impossible that there was considerable underground leakage from old mains and service pipes especially along the water front.

The illegal use of water by business and manufacturing concerns, illustrated by this test, is now known to have assumed amazing proportions throughout our country. It is my opinion that a city confronted by shortage of water supply cannot save itself by adding many meters, or even by adopting the universal meter system. The enormous losses which drain the supply by night and by day through underground leaks and illegal connections not only hasten the shortage of water, but entail a loss in revenue which no city can afford.

Systematic district tests and careful analysis of supply by Engineers of a regularly organized "Bureau of Waste" as in the cities of Washington, D. C. and Pittsburg, Pa. must be made in connection with a judicious introduction of meters.

NOTES ON THE DENSITY, RELATIVE VOLUME AND WEIGHT PER CUBIC FOOT OF PURE WATER.

By M. L. Holman.

The following notes and memoranda are taken from my note-book and from miscellaneous information at hand. It is submitted with the hope that it will save the members of the Association, that may be interested in this subject, some labor and expenditure of valuable time.

1. It is to be understood that where the word pound is used in this paper, it refers to the avoirdupois pound of the United States and the relation of that pound to the kilogram is the relation given in bulletin No. 26 of the United States Coast and Geodetic Survey. When the word meter is used, it relates to the standard of lengths of the United States and the relation of the foot of the United States to the meter is that given in the bulletin above mentioned; that is, that one meter equals 39.37 inches.

The avoirdupois pound of Great Britain is the same as the avoirdupois pound of the United States. The legal value of the yard in Great Britain, however, is such that one meter is equal to 39.370113 inches.

2. In 1826 the British Standard of Mass was defined by saying that a cubic inch of water at 62 degrees Fahrenheit contains 252.458 grains. This definition was based on an Act of Parliament (a).

With this weight of water per cubic inch a cubic foot at the same temperature would weigh 62.32106 pounds avoirdupois. It may he noted, here, that 62 Fahrenheit is the standard temperature used in the determination of specific gravity of various substances by British investigators. At the present time it is common among investigators to use the term "relative density" instead of "specific gravity."

3. Nystrom used this weight per cubic foot of water as his standard for computing the tables which were used by the Navy Department under Chief Engineer Isherwood. Nystrom carried the value to six places of decimals and used the value

(a) Maxwell.

62.321059. In preparing his tables of the density and volume of water at different temperatures Nystrom used a formula, which he deduced from Kopp's experiments, the relative volume at 62 F. being 1.001075. This relative volume gives the weight of a cubic foot of water at 39 F., which was the maximum density assumed by Nystrom, as 62.388055 pounds (b).

4. The Francis table of weight of water per cubic foot used in the Lowell hydraulic experiments is based on the above weight at 62 F. and Hallstrom's relative volumes.

5. Suplee in his Mechanical Engineer's reference book publishes Nystrom's table in full. A table giving densities and volumes of Rossetti is also given (c).

6. Rankine, who is the authority most quoted by engineers in this connection, states that the weight of a cubic foot of water as deduced from the above value given by the Act of Parliament is not correct. The Act of Parliament, which came into effect in 1825, gives the volume of a gallon of water as 277.274 cubic inches. The standard English gallon is stated by Rankine and Clark to be ten pounds of water at a temperaature of 62 F. Rankine and Clark both state that the true volume of the standard English gallon is 277.123 cubic inches. This corresponds to a weight per cubic foot of water at 62 F. of 62.355 pounds (d).

Rankine states that the relative volume of water at 62 F. is 1.001122. (Page 99, Useful Rules and Tables). He also gives the relative volume as 1.001118, which is the volume as given by formula of Professor Miller. (*Ibid.,* Page 146).

Rankine and Clark both assume weight per cubic foot at maximum density to be 62.425 pounds.

7. Porter states in his book, "The Richard Steam Indicator," that the weight of an English cubic foot of water at 62 F. as determined by different commissions is as follows:

French	62.3566	lbs.
English	62.3860	"
Swedish	62.3746	"
Austrian	62.3347	"
Russian	62.3556	"

(b) Nystroms Mechanics, 20th edition, p. 524-526.
(c) The Mechanical Engineer's Reference Book, p. 520-524 (1904).
(d) Useful Rules and Tables, p. 99-146, 2d edition. The Steam Engine, p. 233, 8th edition.

Porter assumes that the value determined by the French Commission is the correct one. For the relative volume of water Porter uses a table which he deduced from Kopp's experiment. The volume at 62 F. assumed by Porter is 1.00109. This gives the weight at maximum density as 62.4245. The maximum density being assumed as 3.945C.

8. From the foregoing it will be seen that at the temperature of 62 F. we have; first, the value based on the Act of Parliament of 1826, viz., 62.321; second, the value as stated by Rankine, Clark and Porter, viz., 62.355. Rankine and Clark both state that the Act of Parliament was partly repealed and also positively state that 277.274 cubic inches is not the correct cubic contents of the standard English gallon.

9. Hamilton Smith gives a table based upon experiments made by Kopp and others and states that it "embodies the most accurate determination thus far made upon the density of water at various temperatures." The weight per cubic foot at 39.3 F. is given by him as 62.424 pounds per cubic foot, and the weight at 62 F. as 62.355 pounds per cubic foot (e).

10. Appendix No. 18. Report for 1890 U. S. C. & G. S. states that in June, 1836, Congress passed the following resolutions: That the Secretary of the Treasury be and he hereby is directed to cause a complete set of all weights and measures adopted as standards, and now either made or in progress of manufacture for the use of the several custom houses and for other purposes, to be delivered to the Governor of each State in the Union, or such person as he may appoint for the use of the States, respectively, to the end that a uniform standard of weights and measures may be established throughout the Union.

The same authority also states that the gallon measure and subdivisions constructed under this Act "have their standard capacity at the temperature at which water has its maximum density, that is, at 3.93C. or 39.07F."

11. Davies & Peck state that the value of the meter employed by the U. S. Corps of Topographical Engineers was the value determined by Hassler in 1832 and was equal to 39.36850154 American standard inches. The same authority also gives the

(e) Chapman Valve Mfg. Co., Catalogue 1888, p. 99 and 100 of Engineering Appendix.

Kater determination of the meter and the kilogram. The United States pound as determined by Hassler was stated to be the weight of 27.7015 cubic inches of water at 39.83F. The barometer being at 30 inches. Hassler also gives the weight of the United States gallon of water at 39.83F. (barometer at 30 inches and 62F.) as 58372.2 grains (f).

The above values for the gallon and the cubic inch corresponds to a weight per cubic foot of water at maximum density of 62.379 pounds, the temperature of maximum density being assumed at 39.83F. (6)

12. Daniel W. Mead in his notes on hydrology publishes a table which he states is partially derived from Kopp's table with interpolations by Oldberg. The weight per cubic foot at maximum density is given as 62.396 pounds per cubic foot, and the weight at 62F. as 62.329.

13. An Act of Congress approved July 28, 1866, made it lawful to employ the weights and measures of the metric system. This Act of Congress included a schedule consisting of tables giving the equivalents of the weights and measures in ordinary use in the United States expressed in terms of the metric system. On April 5, 1893, J. G. Carlisle, Secretary of the Treasury, approved a circular letter of T. C. Mendenhall, Superintendent of Standard Weights and Measures, in which it was stated that in the future the office of Weights and Measures will regard the International Prototype meter and kilogram as fundamental standards, and the customary units the yard and the pound, will be derived therefrom in accordance with the Act of July 28th. The Act of Congress above referred to assumes that the weight of one Liter of water at maximum density is 1 kilogram. The same table also gives the weight of one cubic centimeter of water at maximum density as 15.432 grains. On the above basis we have the weight of a cubic foot of water at maximum density at 62.4283 pounds. It may be stated here that the legal relation of the yard and the meter is $\frac{3600}{3937}$

(f) Dictionary of Mathematics (1856)

and that the legal relation of the pound and the kilogram is $\frac{1}{2.2046}$.

These values and the more extended values where greater precision is desired will be found in Appendix No. 6 to report for 1893 of the Coast and Geodetic Survey, W. W. Duffield, Superintendent.

14. Hering in his Ready Reference Table (vol. 1, p. 45, footnote), notes that Guillaume, in a recent book on International Bureau of Weights and Measures, states that this Bureau has found the Mass of a cubic decimeter of water at 4C to be 0.9999955 kilograms. This gives us as the weight of a cubic foot of water as 62.4255 pounds.

15. Dr. Stokes of the Bureau of Standards of the United States states, in reply to an inquiry on this subject, that the mean results of the International Bureau from 1896 to 1902 give the weight of 1 cubic decimeter of pure water at maximum density as 0.9999724 kilograms. This is equivalent to a weight of 62.42656 pounds per cubic foot. The results of Le Fevre-Gineau and Fabbrone (1779) revised by Mendeljeff gave a weight at maximum density of 62.42583 pounds per cubic foot. The results of the work of Lepinay (1896) gives a weight per cubic foot at maximum density of 62.42577.

16. We may now tabulate the weights per cubic foot of pure water at maximum density as follows:

Hassler	62.379	
Nystrom	62.388	
Mead	62.396	(Kopp-Oldberg)
Rankine and Clark	62.425	
Porter	62.4245	
Smith	62.424	(Rosetti)
International Bureau	62.4255	(Guillaume)
" "	62.42656	(Mean 1896-1902)
Mendeljeff & Lepinay	62.4258	
Metric System	62.4283	

In looking over these figures we readily see that we have two sets, or classes of values, viz., the old and the new.

What may be called the old values are evidently based on

determinations made by English and United States investigators in connection with the determination of the standard gallon of the respective countries. These old values, which are all below the minimum obtained by any of the later day investigators, may be considered as preliminary values and at the present time of historical interest only.

If we take the values to five places only we find that Rankine, Clark and Porter agree on a weight of 62.425 pounds per cubic foot.

International Bureau (Guillaume)	62.426
" " (Mean result, 1896-1902)	62.427
Mendeljeff & Lepinay	62.426
Metric System	62.428

17. It is known that the Liter, which is "the volume of the Mass of one kilogram of pure water at its maximum density and under normal atmospheric pressure," is about 25 parts greater in a million than the cubic decimeter. We, as engineers, thus have the value 62.428 pounds per cubic foot as one limit and the value 62.425 pounds per cubic foot as the other limit, between which limits the true weight lies.

Circular of information of the National Bureau of Standards No. 4. Table of Equivalents of the customary and metric weights and measures states that "all capacities are based on the equivalent, 1 cubic decimeter equals 1 Liter."

We have the legal weight of a cubic foot of water at maximum density, expressed in five places of figures as, 62.428 pounds.

The mean results of the International Bureau (1896-1902) indicates a weight of 62.427 pounds per cubic foot. It is probable that the value ultimately adopted for the Liter will not change this figure.

18. The relative volume of water at different temperatures has been determined by a number of experimenters. The earliest values with which I am acquainted are those of Dalton, the celebrated English Physicist, and are given by Haswell as follows:

Temp.	Vol.	Temp.	Vol.	Temp.	Vol.	Temp.	Vol.
22	1.0009	52	1.00021	112	1.0088	172	1.02575
32	1.	72	1.0018	132	1.01367	192	1.03265
46	1.	92	1.00477	152	1.01934	212	1.0466

Volume at maximum density, 39.1F. is 1.0000.

The relative volumes most quoted are those of Kopp (1847). Since Kopp's experiments were made a number of other experiments have gone over the field and have obtained slightly different results. For a temperature of 62F. we have relative volumes as follows:

Nystrom (based on experiments of Kopp)	1.001075
Clark	1.00101
Rankine	1.001122
Oldberg (based on experiments of Kopp)	1.001078
Porter " " " " "	1.00109
Rossetti	1.001107
Rankine (formula of Prof. Miller)	1.001118
Formula given by Morton	1.001114
Reichsanstalt (1896)	1.001144

The National Bureau of Standards states that "the best information we have on hand at the present time is contained in the table depending upon the work of the Reichsanstalt. This work was done in 1896 by Thiessen, Scheel and Disselhorst." The following table gives the densities and I have added the relative volumes and the logs of the volumes and densities.

Temp.	Density.		Log Density.		Log Vol.	Vol.
0	0.999	8676	9.999	9425–10	0.000	0575	1.000132
1		9266		9681		0319	074
2		9680		9861		0139	032
3		9922		9966		0034	008
4	1.000	0000	0.000	0000	0.000	0000	1.000000
5	0.999	9918	9.999	9965–10	0.000	0035	1.000008
6		9680		9861		0139	032
7		9293		9693		0307	071
8		8759		9461		0539	124
9		8084		9168		0832	192
10		7271		8815		1185	273
11		6324		8403		1597	368
12		5246		7935		2065	476
13		4041		7411		2589	596
14		2713		6834		3166	729
15		1264		6205		3795	874
16	0.998	9697		5523		4474	1.001031
17		8014		4791		5209	1200

Temp.	Density.	Log	Density.	Log	Vol.	Vol.
18	6220		4012		5988	1380
19	4315		3183		6817	1571
20	2303		2307		7693	1773
21	0186		1386		8614	1985
22	0.997 7966		0420		9580	2208
23	5645	9.998	9410–10	0.001	0590	2441
24	3225		8356		1644	2685
25	0708		7260		2740	2938
26	0.996 8097		6123		3877	3200
27	5391		4943		5057	3473
28	2594		3724		6276	3755
29	0.995 9708		2466		7534	4045
30	6732		1168		8832	4346

20. If we take from the above table the relative volume at 62F. (16-2-3C) as 1.001144 we will find by applying it to the legal weight at maximum density that we have as the weight per cubic foot at the temperature of 62F. 62.357 pounds. If we use the weight of 62.426 pounds per cubic foot derived from the average of the International Bureau, we have as the weight per cubic foot at 62F. the value 62.355 which agrees with the value used by Rankine.

It would appear that we, as engineers, are in the same relative position that Rankine and Clark found themselves; that is, our legal weight and our actual weight per cubic foot do not agree. They are, however, nearer together than the values of Rankine's time.

21. A number of formulae have been proposed for the relative volumes of water at different temperatures.

Rankine gives two: First, an approximate formula of his own devising which is as follows:

$$V = \tfrac{1}{2}\left(\frac{T+461}{500} + \frac{500}{T+461}\right)$$

V: Relative volume at temperature T degrees F. the volume at maximum density being 1. In this formula Rankine assumes the absolute temperature of maximum density as 500 F° (absolute) and the absolute zero as –461 F°; 2nd, a more accurate formula as follows:—

$$\log. V = \frac{10.1\ (T-39.1)^2 - 0.0369\ (T-39.1)^3}{10{,}000{,}000}$$

V is relative volume at T° F and the 7 place log of v. is given by the formula. The formula is for a range of temperature from 32° to 77° F only. (4)

22. The formula used by Nystrom was deducted from experiments by Kopp and is:—

$$V = \frac{(T-39)^2}{200{,}000\ (0.23+0.0007\ (T-39))} + 1$$

23. A formula recommended by Alex. Morton is of the form

$$V = 1 + \frac{a(T-39.2)+b(T-39.2)^2+c(T-39.2)^4}{(T+461.2)^2}$$

in which

V=relative volume of water at temperature T° F

log a=9.456 8213–10
log b=9.757 8513–10
log c=4.429 9621–10

24. Various formulæ of the form

$$V = 1+at+bt^2+ct^3$$

have been used.

25. The relative volume at 100 C or 212 F. is given by different experimenters as follows:

Kopp (1847)	1.043125
Kopp (as corrected by Porter)	1.04332
Nystrom (deduced from Kopp)	1.042622
Despretz (1839)	1.043150
Hagen (1865)	1.042969
Matthieson (1866)	1.043159
Rossetti (1868)	1.043116
Rossetti (1871)	1.04312
Jolly (from Ingenieurs Tashenbuch 1877)	1.043116

We see from the above table that Rossetti, who experimented to a considerable extent, finally came around to Kopp's value or practically so. At the present time the most reliable value we have is that of Rossetti. His relative volume at the 100 C. ap-

plied to our previous weights per cu. ft. at maximum density give us a pair of values as the weight of water per cu. ft. at the boiling point, viz:—

Weight based on legal or metric system.....59.8477 lbs.
" " " mean results I. B.....59.8455
Rankine's approximate formula (Clark) gives....59.76
Nystrom 59.838
Smith (Rosetti) 59.843
Clark states that the actual weight is.....59.64
Kent states that values range from 59.56 to.....59.845

26. We may now state the case as follows:—

Weight of water per cubic foot

At maximum density (*Legal or metric system*)....62.428
At 62F. 62.357
At boiling point, viz:—100C. or 212F. 59.848
At maximum density, *mean result I. B.* 62.427
At 62F. 62.355
At 100C. 212F. 59.846

27. It has been found that, where great precision is desired, one formula will not cover the range of temperature from freezing to boiling point. The specific heat of water is not constant between the freezing and boiling points, hence two or more curves will, in all probability, be required to accurately and precisely represent the relative volumes for each degree of temperature from the freezing to the boiling point.

28. The following table of relative volumes is given for general comparison:—

Temp. C.	Despretz. 1839	Kopp. 1847	Rosetti. 1871	Reichsanstalt. 1896	Jolly Hütte.
0.	1.000137	1.000123	.....	1.000132	1.000126
10	1.000268	1.000247	1.000253	1.000273	1.000257
20	1.001790	1.001690	1.001744	1.001773	1.001732
30	.....	1.00423	1.00425	1.004346	1.004234
40	1.007730	1.00768	1.00770	.....	1.007627
60	1.016980	1.01672	1.01691	.....	1.016954
80	1.028850	1.02871	1.02887	.....	1.029003
100	1.043150	1.04312	1.04312	.....	1.043116

29. The Bureau of Standards in a letter previously referred to state that both the expansion of mercury and of water were

determined by Chappius at the International Bureau in 1903, but the results are not yet accessible. When the International Bureau announces its final results the questions of the actual weight of pure water per cubic decimeter and the relative density at different temperatures will in all probability be settled so far as human skill can settle it.

Until such time as the International Bureau publish their results, it is hardly worth while to perform the labor necessary for the calculation of the relative densities and volumes of water for each degree between freezing and boiling points. The table of Kent is sufficiently close for rough work and the table of Hamilton Smith gives very good results to five significant figures. For pumping engine trials where greater accuracy is desired, the table giving the volumes and densities as determined from the work of the Reichsanstalt may be used.

President Sherrerd: If there are no remarks on this paper, it will be published in the usual manner in our reports.

Dr. Mason: I have very little to say about the paper more than to express my appreciation of the great need of having this question settled by competent authority. I very well remember some years ago of a boy stepping into my laboratory with a telegram coming from one of the officials of the Standard Oil Company. It read, "Wire us at once weight of a gallon of water in grains, four decimal places, at 60 degrees Fahrenheit." I said to the boy, "Just wait a minute, I will write a telegram." I thought it was the simplest thing imaginable to do. I couldn't understand why they had sent so simple a problem to me. All I had to do I thought was to go to my library and write the telegram at once. I didn't keep that boy waiting, because it took me just three months to write that telegram—and when I wrote it, it was not right. I found if I only had books enough I could get any kind of a result to wire those people. The few authorities who agreed had taken the results from each other. I found as a matter of interest to me that there was but one pound fixed by statute in the United States, and that was the Troy pound, which had been brought from England for use in the Mint. It may be worth while stating that we now, in this country, possess the standard Troy pound.

We sent over, you remember, years ago a commission to copy the English standard. They brought such copy here, and it is now in the mint at Philadelphia. Since then the British pound has been burned up, so we possess the standard. That is the only weight except those of the metric system that is upon the statute books today, all other weights being recognized merely in common law. I sincerely hope that something like an authoritative statement from the people who know all about these things well come out and tell us just where we are.

Mr. Hague: This story about a telegram from the Standard Oil Company by Dr. Mason is enough to "rock a feller" to sleep right here! I am well acquainted with Mr. Holman, and I know what a deeply serious man he is. He has evidently given a great deal of time and attention to this matter of the weight of a cubic foot of water at various temperatures. I had understood he was to be here. He would have had something of very great interest to say on this subject, although it looks to me a simple proposition on the part of the filter people to give us a foot of pure water.

THE SOUTH BETHLEHEM IMPROVED SLOW SAND FILTER PLANT AND THE KITTANNING "SEMI-RAPID" FILTER PLANT.

By P. A. Maignen.

On different occasions the writer has drawn the attention of the members of the American Water Works Association to various improvements in slow sand filtration; and, last year he described the construction and operation of the lower Roxborough preliminary filters. These preliminary filters or scrubbers have now been used for a year and a half and have been found to fulfill all the conditions of the contract with the City of Philadelphia, which contract called for guarantees as to efficiency, cost of operation and maintenance. This installation has demonstrated beyond peradventure that preliminary filtration is a success and a necessity when it is desired to obtain from slow sand filters a rate of filtration in excess of 1,600,000 gallons per acre, per day.

The plain, slow sand filters of lower Roxborough, which have received Schuylkill water prepared by the preliminary filters, have worked most satisfactorily, at rates varying from four to seven million gallons per acre, per day, and have yielded an excellent quality of filtered water.

The results obtained by Messrs. Hering and Fuller, with experimental filters in Philadelphia, have been realized on a large scale at Lower Roxborough; the daily output of this station varies from eight to twelve million gallons per day.

The writer will now describe two new filter installations designed by him and constructed during the past year, namely, the South Bethlehem "improved slow sand" filter plant and the Kittanning "semi-rapid" sand filter plant. The construction was begun, in both cases, in April, 1904; the filters were put in service, at Bethlehem, in November, 1904; and at Kittanning in February, 1905.

SOUTH BETHLEHEM "IMPROVED SLOW SAND" FILTERS.

The water supply of South Bethlehem is drawn from the River Lehigh. It is soft and usually free from any great number of bacteria. In times of freshets a considerable amount of

fine culm floats in the water and makes it as black as ink. Some industrial establishments allow their refuse, mostly iron, to reach the river, and this makes the water at times quite red. But these impurities are in suspension and do not affect the chemical quality of the water, which is always very good. The nature of the water-shed and the rapid flow of the river prevent the accumulation of organic mud in the bed of the river, and the water is at all times free from objectionable odor or taste.

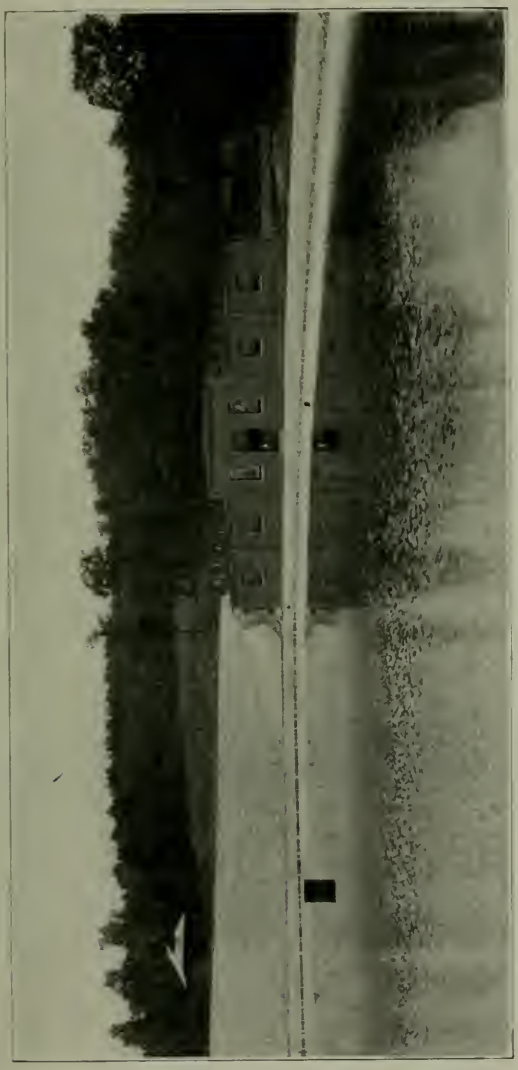
Epidemics of typhoid fever, however, have occured during the last few years, particularly after the snow freshets, and they have forcibly brought the question of water purification to the front. The Bethlehem City Water Company, being desirous of guarding their water supply against any taint or danger from temporary pollution, decided at the beginning of 1904 to have recourse to filtration.

The first thought was in favor of mechanical filtration, because the first cost of installation is less than that of slow sand filtration. But the water being soft and generally clear it was found that sulphate of alumina would not be decomposed without the addition of alkalies and this would have rendered the cost of maintenance prohibitive. The late Dr. Drown, Dean of the Lehigh University, expressed a decided preference for slow sand filtration; he was joined in this opinion by the professors of the University and by the general public, and at this particular time information was published showing that the cities in which mechanical filters are used were not free from typhoid fever. The water company charged the writer with the duty of designing as complete and perfect a slow sand system of filtration as he knew how with instructions to spare no expense for what would be likely to improve the quality of the water to the highest degree whilst he was to avoid all unnecessary accessories or embellishments.

The pumping station is confined between the river bank and the Lehigh Valley Railway and there is absolutely no space available for a filter plant of any kind at this location.

The water is pumped into a storage reservoir erected on a hill 265 feet above the river and having a capacity of 15,000,000 gallons. On the slope of the hill and at a lower level, 20 feet below there is a distributing reservoir containing about 5,000,000 gallons of water.

There was on one side of the hill, adjoining the basins, a small piece of ground that could be utilized for a filter site, and it was found that, by adding to it an embankment, sufficient

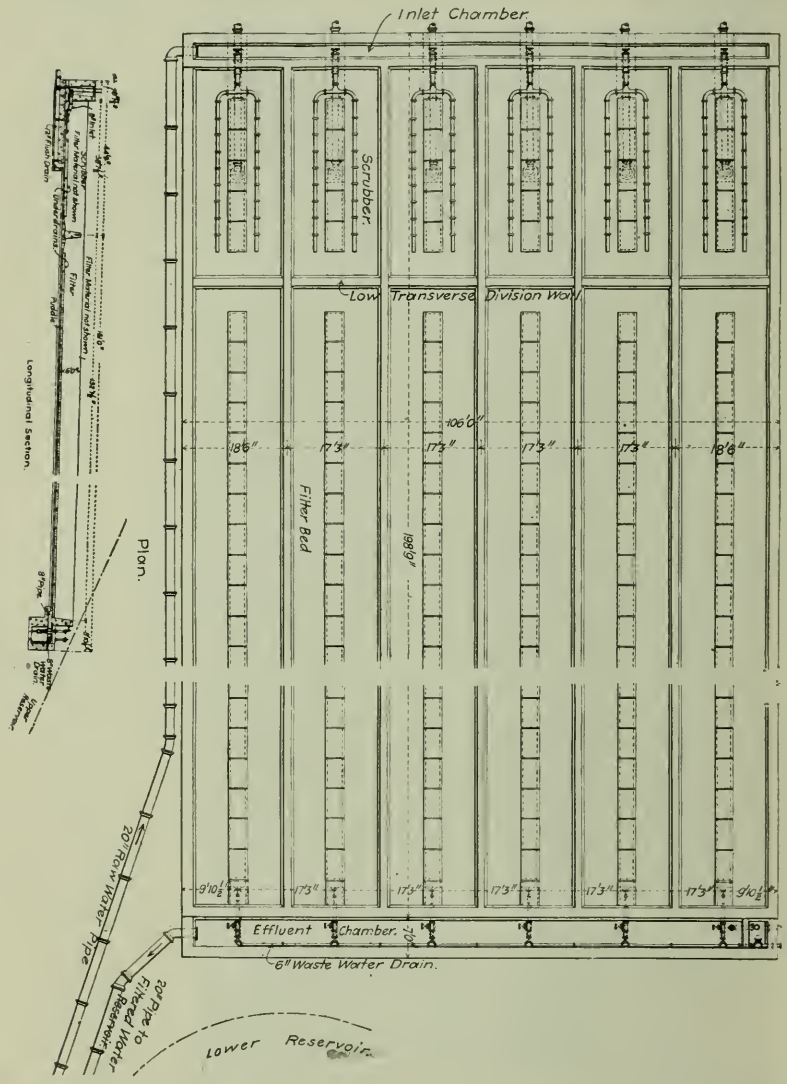


THE FILTER PLANT, STORAGE AND FILTERED WATER RESERVOIRS, SOUTH BETHLEHEM WATER WORKS.

space could be obtained for the erection of a filter plant. The water would flow from the upper storage reservoir to the filters by gravity and from the filters to the lower basin also by gravity.

GENERAL DESCRIPTION.

The nominal capacity of the filter plant is 4,000,000 gallons per day; at present the average consumption is 2,500,000 gal-

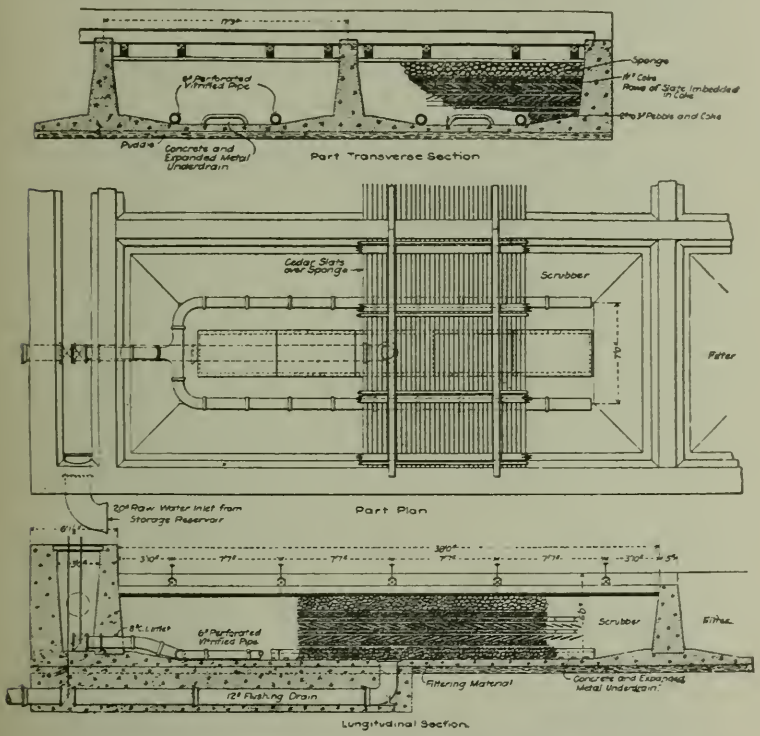


GENERAL PLAN OF SCRUBBERS AND FILTERS AND A LONGITUDINAL SECTIONAL ELEVATION THROUGH THEM.

lons per day. It is necessary to maintain the lower basin always full of filtered water in order to reach the highest parts of the

town; consequently, the filters have to be regulated to meet the varying demand of the consumers; this variation, however, is not very great because the railway companies take water during the night.

In case of fire, the filtered water basin is allowed to be drawn upon to supply the extra demand so that at no time is it found necessary to let raw water go into the mains.

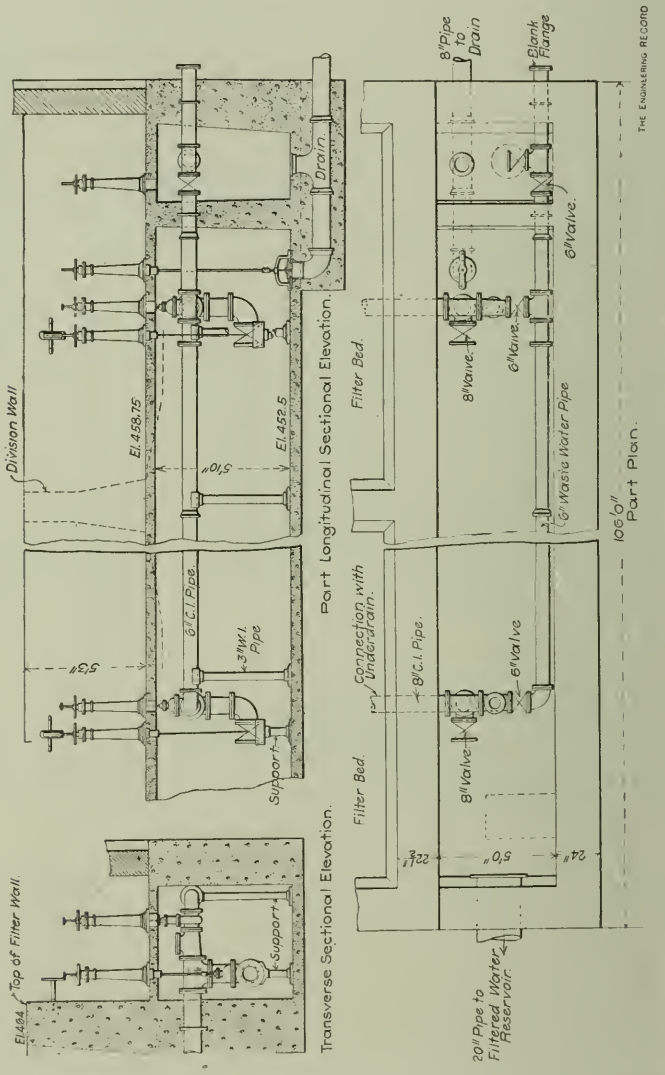


DETAILS OF FILTERING MATERIALS AND PIPING CONNECTIONS OF SCRUBBERS.

The water from the upper storage basin comes through a 20-inch pipe to the far end of the filter house into a gullet three feet wide, eight feet deep, extending the whole width of the building. The admission of water into this influent gullet is regulated by a stop valve, inside the building.

There are six units of scrubbers, 16 feet wide, 38 feet long, 6 feet deep and six units of final filters 16 feet wide, 152 feet long, 6 feet deep. The water from the influent gullet enters

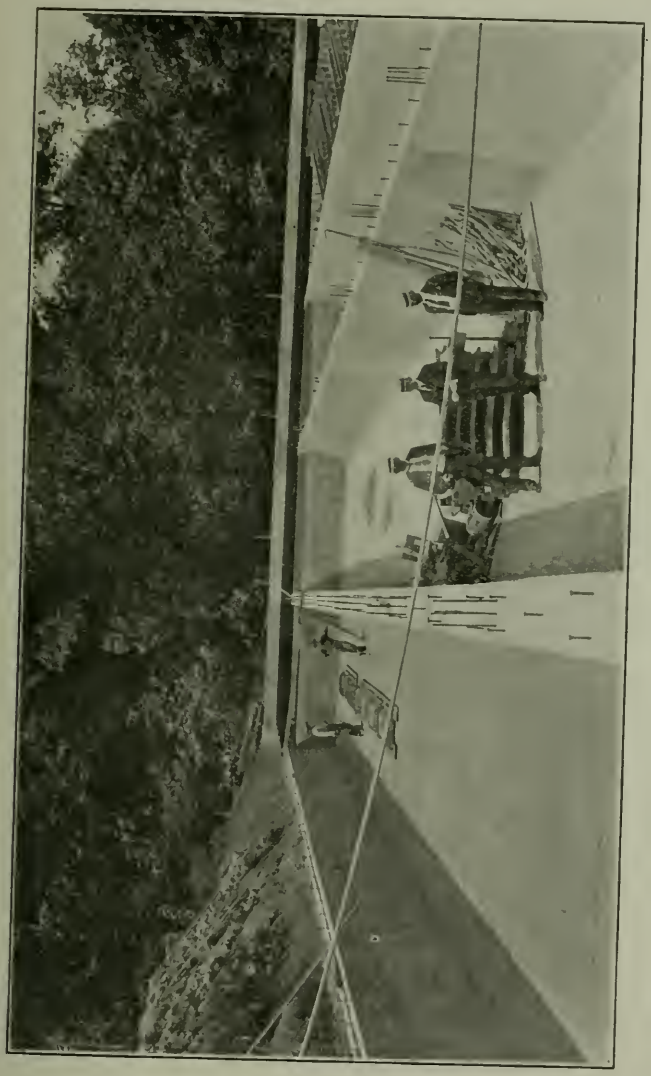
the bottom of the scrubbers through 8-inch valves (regulated from the floor over the gullet) and it rises upwardly through the scrubbing materials within 6 inches or 8 inches of the top of the side division walls and flows naturally to the filter beds,



DETAILS OF PIPING IN THE EFFLUENT CHAMBER.

which are on the same line, and are only separated from the scrubbers by a dwarf wall. When in normal operation, the level of the water on the scrubbers and on the filters is the same, and there is practically no motion on the surface. The only

movement that is noticeable is the escape of air at the top of the scrubbers. It should be stated here that the air held in solution by the river water is often the cause of considerable



CONCRETE TANKS DURING CONSTRUCTION.

trouble in downward sand filters of the slow or rapid types; it accumulates in the sand and prevents filtration. This phenom-

enon has given rise to much discussion on what has been called positive and negative heads, and it has led to the construction of filters with a minimum positive head of four feet (height of water above the sand). It so happens that in passing upwardly through the scrubbers, which as is known are composed of very coarse or open materials, the water frees itself of this "Constitutional" air, and no trouble whatever is met with from this cause in the operation of the sand filters, receiving scrubbed water.

In the final filters the water flows downward, in the usual way, through the filtering materials, and comes out into the effluent gallery, which is six feet deep, through 8-inch valves which are always submerged in water. Provision is made at the end of each filtered water outlet for wasting the first filtered water through a six-inch valve, attached to a pipe connected with the different filter units, and allowing also back filling with filtered water.

The division and end walls as well as the floors of the scrubbers and final filters are constructed of concrete reinforced throughout with half-inch square iron bars.

Wherever the floors are over made-ground, expanded metal has been added to the iron bars. The concrete was worked very wet and was trowelled against the forms.

There have been no settlement cracks, but a few shrinkage cracks have shown themselves in the keys. These were easily repaired and no leak has occured in the concrete work during the last winter, which was particularly severe.

Over the filtered water gallery is a reinforced concrete floor through which the stems of the effluent valves and re-wash valves pass. These stems are supported by indicator stands, which help to regulate the flow of filtered water. This space may be called the gate chamber. There is plenty of room for the manipulation of the valves, the reading of the loss of head gauges and the sampling of each filter unit. The water in the effluent or filtered water gallery is at the same level as in the lower basin, with which it communicates by a 20-inch cast-iron pipe.

The outer concrete walls serve as foundations for the walls of the building, which are made of brick. The roof is of wood

with a white pine ceiling and slag covering; it is supported by cast iron pillars which rest upon the division walls. There are windows every 17 feet, all round the building; the center of the roof is raised and is provided with sidelights. The whole filter house is as light as a living room.

DRAINAGE AND FILTERING MATERIALS.

The distribution system in the scrubbers consists of two 6-inch lines of perforated terra cotta pipe laid at the bottom and the drainage system is composed of concrete slabs 3 feet wide, 8 inches high. A 12-inch washout pipe leads the dirty wash water from the center of the scrubber to the main drain, outside.

The materials used in the scrubbers, beginning from the bottom, are:—

1. A nine-inch layer of three-inch pebble stones.
2. A nine-inch layer of coke, "egg" size.
3. Twenty-four inches of space is occupied by four rows of slates placed at a slight angle upwardly, each row in a contrary direction, so that the water in its upward flow is compelled to take a circuitous or spiral course. The space between the slates is occupied by coke, "nut" size.
4. An eighteen-inch layer of sponge, held down by cedar slats, yellow pine stringers, wood blocks and steel "I" beams fastened on the walls.

The drainage system in the sand beds or final filters is similar to that of the scrubbers. It consists of convex slabs made of concrete, with openings at the base. These slabs are laid in the center of the bed whose floor is dished. A perfect drainage is thus secured and no stagnant water can remain in any part of the filter bed.

The materials used in the final filters, beginning from the bottom are:—

1. Eighteen inches gravel, graded from 3 inches to 3-16 inches.
2. Two feet of filter sand.

The gravel and the sand were obtained from Birmingham, N. J., and Haynesport, N. J. They were graded according to the specifications of the City of Philadelphia.

There is about twenty-four inches of water above the sand.

CLEANING.

One of the features of the South Bethlehem plant is the cleaning operation. A yellow pine coping is laid on the division walls and flat steel rails are set thereon. A crane travels on these rails and an arrangement is made for the transfer of the crane from one bed to the other.

The crane is used for the following purposes:

1. A platform attached to the crane is lowered close to the sand bed for the collection of the dirty sand and it is raised for transfer from one filter unit to the other. The man who scrapes the sand stands on the platform, and when the platform is loaded, the crane is pushed toward the sand washer by men walking on the division walls so that at no time have the men to set foot on the sand bed itself. The same device is used to receive the clean sand and distribute it over the bed.

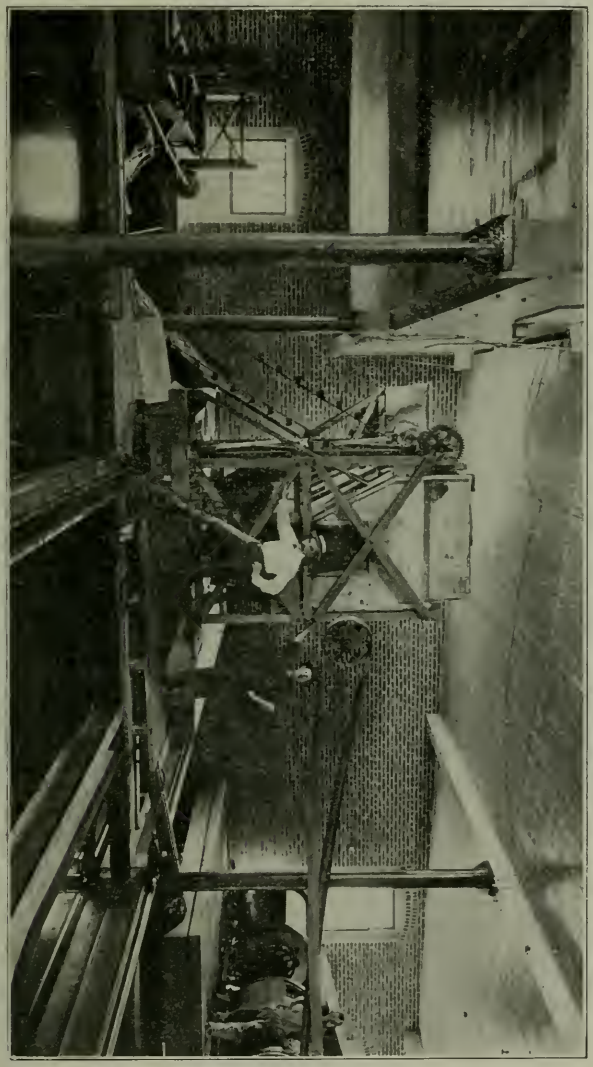
2. The crane and platform are also used to level or plane the sand layer after it is replaced on the bed.

3. A trough erected on the crane is used for the distribution of artificial filtering membranes, concerning which more will be said on a subsequent occasion.

SAND WASHER.

The Sand Washer used at South Bethlehem is an entirely new device. It consists of four bucket elevators with suitable framework, shafting, countershafting and a trough. It is operated with an electro-motor which is also used for the sponge-washing machinery. The sand washing machine and the sponge washing machine are erected on platforms which are moved on the "I" beams of the Scrubber close to the filter in process of cleaning. The crane and platform bring the dirty sand to the washer, it is shovelled from the platform into a boot not more than two feet high, where it is taken up by the first elevator. It is raised some nine feet in the air and then made to drop with a certain force into the water of the trough below; the sand is taken up again by a second elevator, raised and dropped in the water as before; it is lifted a third time and again thrown in the water, the fourth and last time it is raised from the washing trough and falls in a chute which leads the

clean sand to the travelling crane for distribution on the bed. In this process each particle of sand comes in direct contact,



THE TRAVELING CRANE AND SAND WASHER IN POSITION FOR OPERATION.

more or less violent with the water which it strikes, it is freed from mud by the force of impact. The sand is handled in very

small quantities at a time, is not subject to the law of currents and never forms any stratification.

The wash water enters in the trough from the far end which receives the clean sand and goes out at the near end which receives the dirty sand. The flow is regulated so as not to carry away any of the fine sand.

The following are some of the advantages of this new system:

1. Very little water is required, it need not be filtered water, nor has it to be under pressure.

2. The sand is washed as soon as scraped without remaining in heaps, in courts, exposed to wind, rain, frost, dust, etc.

3. The sand being washed fresh, the mud comes off easily, and being replaced on the bed as soon as washed, the filtering layer is always of the same thickness.

4. The sand is at no time stratified as is the case with the ordinary methods of washing.

5. Nor is there at any time any waste or separation of the finer particles of sand, which are absolutely necessary to produce good filtration. By the ordinary system of washing sand, there is considerable separation of the different sizes of particles, according to their specific gravity, and much waste of the finest particles; this renders the efficiency of the filter less and less after each cleaning. With the system inaugurated at South Bethlehem, the physical condition of the sand is always the same.

The scrubbers are cleaned as at lower Roxborough, and the reader is referred to the writer's communication on the subject. The only difference between the two installations is that at Roxborough the sponge has to be hoisted up in large baskets and conveyed by an overhead tramrail to a side building for washing. At Bethlehem the sponge washing machine is placed on a movable platform close to the Scrubber undergoing cleaning, so that the sponge can be carried to the washer in small baskets by hand.

OPERATION.

The work of the South Bethlehem scrubbers has been so efficaciously performed that the sand filters have required but

one scraping since the plant was put in operation six months ago. The fine culm agglomerated on the surface of the Scrubbers has been utilized to form a natural Schmutzdecke or filtering membrane on the sand. Once a month the water in the final filters has been lowered and the sand has been raked half inch deep.

The sand being discolored fully 1½-inch deep, the main part of the so-called Schmutzdecke was not disturbed by the surface raking, and the speed has been maintained without any

INTERIOR OF FILTER BUILDING FROM THE FLOOR OVER THE INLET CHAMBER.

reduction in the quality of the filtered water. With a view of obtaining from this filter plant the highest possible degree of efficiency and the greatest yield, it will in future be worked with artificial filtering membranes, preferably with asbestos fibre, deposited on the surface of the sand, as described by the writer on previous occasions, notably at the New York Convention.

What we want here to emphasize as points worthy of interest in the South Bethlehem plant are the following features:—

1. Light and well ventilated filter house.

2. Narrow filter beds and comparatively small units. One-eighteenth of an acre instead of the usual large units of half, three-quarter, or whole acre.

3. Shallow layer of water over the sand bed, showing the possibility of reducing the height of the filter walls to a minimum.

4. Cleaning without trampling on the sand.

5. Washing the sand without losing the fine particles or separating it in different grades.

6. Avoiding sand courts with the waste and pollution resulting from exposure.

7. High speed of filtration from six to nine million gallons per acre, per day.

8. Long runs of three months or more without scraping.

9. No coagulation.

10. Facilities for distributing and removing the filtering materials, and forming the artificial membranes.

11. Compactness, simplicity and easy control of the whole plant.

12. No constant labor of any kind, the attendant hitherto in charge of the reservoirs, regulates the flow of the water through the filters to suit the requirements of the town. He attends to the filter valves instead of attending to the reservoir valves.

When a cleaning operation is necessary, it is carried on by the ordinary staff of the water company.

13. The mechanical power required for all the washing operations is supplied by a 5 H. P. electrical motor.

TEST OF QUALITY.

The water is examined daily through a two-foot tube. The filtered water must be absolutely brilliant. That of the scrubber may be slightly yellow but must be clean. Of course the water in the effluent gullet viewed through the tube appears always dark brown or quite black. The loss of head gauges indicate when it is necessary to perform the cleaning operations.

The following are the chemical analyses of the water of South Bethlehem made before and after filtration by Dr. Chandler, Professor of Chemistry, at the Lehigh University:

TABLE I.—ANALYSES OF RAW AND FILTERED WATER.

	River water. Parts per million.	Filtered water. Parts per million.	Removal per cent.
Mineral solids	70.5	55.0	22.00
Organic solids	17.5	5.0	71.40
Total solids	88.0	60.0	31.26
Nitrogen as free ammonia	0.031	0.007	99.00
Nitrogen as albuminoid ammonia.	0.033	0.016	51.50
Nitrogen as nitrites	trace	none	trace
Nitrogen as nitrates	0.76	0.59	22.30
Chlorine	2.54	2.54	none
Oxygen consumed	1.20	0.62	48.30
Hardness, cal'm carb	45.00	32.50	27.80
Hardness, permanent	35.10	26.00	25.90
Hardness, temporary	9.90	6.50	34.34

The sample of raw water was taken from the river opposite the intake of the pumping plant at 10:30 a. m., January 17, 1905. The sample of filtered water was taken from a tap on the distribution system at 11 a. m., January 17, 1905. The percentage of removal is by subsidence in the reservoirs and by filtration.

Tests made under the direction of Dr. Thomas Darlington, Commissioner of Health of New York City, to determine the bacterial efficiency of the South Bethlehem Filter Plant.

TABLE II.—BACTERIAL EFFICIENCY OF FILTERS.

Nature of sample.	Bacteria.	B. coli.
Raw river water	3250	50.0
Water from storage reservoir	2550	50.0
Effluent from scrubbers	720	10.0
Effluent from sand filter	38	.2
Water from tap in town	62	.2
Bacteria removed from river water by whole process, per cent		98.48
Bacteria removed from river water by filters, per cent		98.48
Colon bacilli removed from water by filters alone, per cent		99.6

Samples collected May 10, 1905.

Bacterial analysis made to ascertain the efficacy of the filter plant in relation to the removal of Coli Bacilli and other gas-producing bacteria, with the following results:

UNFILTERED WATER.

1904

Oct. 19—Gas in 4 out of 5 tubes of 1 C. C. of water from river.

Oct. 20—Gas in 4 out of 4 tubes of 1 C. C. of water from river.

1905

Feb. 15—Gas in 5 out of 5 tubes of 2 C. C. of water from river.

FILTERED WATER.

1904

Dec. 10—No gas in 200 C. C. of water from spigot at the University.

1905

Feb. 15—No gas in 10 C. C. of water from spigot at the University.

Feb. 15—No gas in 10 C. C. of water from spigot at the University.

Feb. 15—No gas in 10 C. C. of water from spigot at West Bethlehem.

Feb. 15—No gas in 10 C. C. of water from the scrubbers.

The most practical test of a filter plant is its effect upon the health of the community. This has been very satisfactory in the territory supplied by the Bethlehem City Water Co.

The following is extracted from the official registers of the Board of Health:

TYPHOID AND ENTERITIS IN SOUTH BETHLEHEM.

	1903.		1904.		1905.	
	Cases.	Deaths.	Cases.	Deaths.	Cases.	Deaths.
January	17	4	5	5	0	0
February ...	6	14	6	5	1*	0
March	69	7	0	4	0	0

GENERAL DEATHS IN SOUTH BETHLEHEM.

	1903.	1904.	1905.
January	30	32	19
February	26	26	21
March	23	27	17

It is seen by the above statement that typhoid fever has been

*Hospital Case.

prevented and that the general death rate has been materially reduced.

THE KITTANNING "SEMI-RAPID" FILTERS.

The physical conditions of the water supply at Kittanning, Pa., resemble those of Bethlehem in many respects. The water is taken from the river Allegheny and pumped into a sedimentation reservoir on a hill. There is also a distributing reservoir with a difference in level of about thirty feet between the two.

CHOICE OF A FILTER.

The Kittanning Water Works belong to the Armstrong Water Company.

The erection of a slow sand filter was out of question because no land could have been conveniently found in the neighborhood and the expense would have been too great. The only available site for the location of a filter plant was a small strip of land between the two reservoirs.

The consumption of water at Kittanning is 1,000,000 gallons per day. The storage reservoir above and the distributing reservoir below, allow the filters to work at an even rate day and night. The filter house is a brick building, 30 feet wide and 100 feet long, with a slate roof. It contains five filter tanks 15 feet in diameter and 14 feet high. These tanks, which are made of cypress wood, are divided in two sections.

The upper section acts as scrubber and the lower section as final filter. The materials used in the scrubbers are the same as those of Roxborough, namely stone, coke and sponge. The filters have an underdrain composed of 18 inches of crushed stone graded from 3 inches to 3-16 inch, and a filtering layer of crushed quartz sand, three feet thick.

The quantity of water filtered daily is 1,000,000 gallons, and the rate of filtration in the scrubbers and final filters is 48,000,000 gallons per acre, per day.

Butterfly valves at the entrance to each filtering unit and at the end of the general effluent pipe render the whole plant automatic, so that no attention is required, either day or night, except when the filters require cleaning.

In this installation advantage is taken of the full pressure of the water on the sand (positive head of about 8 feet) to insure the "semi-rapid" rate of filtration for which the plant has been designed.

The Allegheny water at Kittanning contains a certain amount of mine water, with lime, iron and sulphur. When exposed to the air in the storage reservoir and when passing through the scrubbing materials, a red precipitate is formed. It presents on the top of the scrubbers, a flocculent appearance similar to that produced by artificial coagulants. This flocculent material forms an excellent Schmutzdecke on the sand.

The Kittanning filter plant was placed in service on the 19th of February, 1905, just one day before the beginning of high water. The filtered water has been as brilliant as crystal ever since. The scrubbers have not had to be cleaned yet and will probably not require this operation for several months to come. They have, however, been drained several times to remove the coarsest sediment which accumulates in the lower part of the scrubbing materials.

The sand filters have been washed by reverse current once a week.

The first wash water used for the operation comes from the storage reservoir. It enters the bottom of the sand bed with a pressure of about 12 pounds. When the sand has been well loosened, the reservoir water is shut off, and the filtered water from the working filters with a pressure of about three pounds, is made use of to complete the washing. The first filtered water is allowed to go to waste.

It has occurred to the writer that the Kittanning filter system of "semi-rapid" filtration might be of some interest to the members of the Association.

THE PRACTICAL STERILIZATION OF PUBLIC WATER SUPPLIES BY MEANS OF COPPER-IRON SULFATE AND FILTRATION.

C. ARTHUR BROWN.

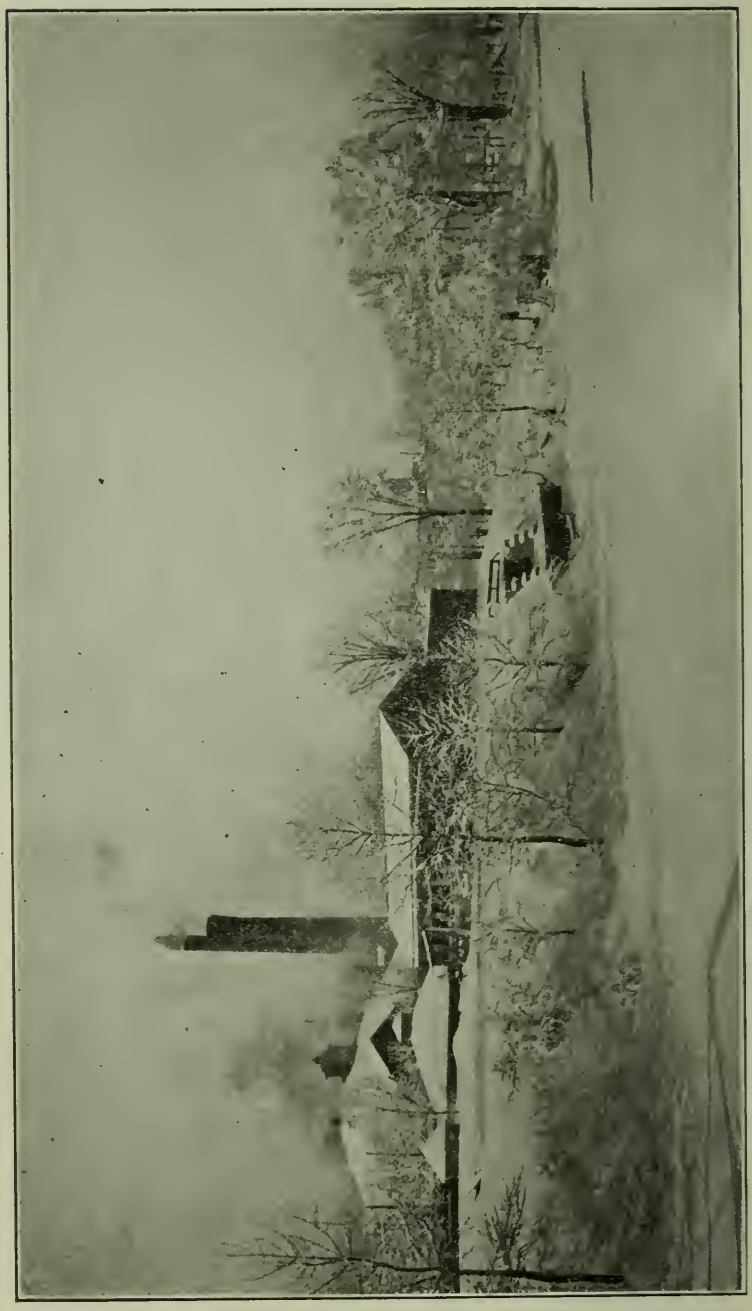
Mr. President and members of the Association: The paper which I am to present deals with an advancement recently made in the art of water purification. I am sorry that it must be only a report of progress, but this progress is so conclusively proven and the improvement is of such vital import that I feel justified in bringing it before you.

When the Bureau of Plant Industry, through Bulletin No. 64, gave us the results obtained by the use of copper sulfate in the destruction of algæ and announced its toxic effects on the *Bacillus typhosus* and its slightly inferior toxicity to the *Bacillus coli communis*, I, with many others, accepted the statements therein with some doubt and incredulity. I did not question the veracity or earnestness of those standing sponsors for the statements made in the Bulletin, but the results given were so new and startling that I found it difficult to believe them in their entirety.

Having my doubts, I set to work to verify or disprove them. I presume others present did the same thing. I found that the statements made were true. One part of copper sulfate did kill the *B. typhosus* and *B. coli communis* when used in proportion of 1 to 100,000.

I also ascertained that if sulfate of copper was added to a normal water it apparently took some time to complete its work, and that under some conditions it did not completely precipitate itself in a short enough time to be available for use in connection with filters of the mechanical type. And I reasoned that if it was to be of any great service in water purification this was the most practical field for it.

Many filter plants of earlier construction had only a very limited time period between the introduction of the chemicals into the water and passage through the filters, as in the standard Jewell type. One of the plants I was in charge of was of this form of construction. The time pe-



GENERAL VIEW OF WATER WORKS, ANDERSON, IND. FILTER PLANT IN THE FOREGROUND.

riod between treating and filtering in this plant was only fourteen minutes when the filters were being crowded, and I found as far as laboratory experiments would go it sometimes took twelve hours and longer for the reaction between the sulfate of copper and the salts of the natural water to be sufficiently complete to insure perfect elimination of the copper. The shorter the time the greater the apparent tendency of the copper to pass the filters. As very few mechanical filters had this period of sedimentation the apparent field of usefulness was really very small.

While all the evidence at hand then, and that since obtained, seemed to argue that no evil could result in using a water containing only traces of copper, I did not want to further a scheme that would continuously furnish a water containing even a trace of copper sulfate.

Two of the filter plants under my care at that time were using sulfate of iron. When sulfate of iron is added to a natural water it exhibits the same tendency as did the copper sulfate. To overcome this difficulty caustic lime is added to the water in sufficient quantity to absorb all the free and a portion of the semi-combined carbonic acid. When this is done a very rapid and complete precipitation of the iron sulfate occurs and the resulting filtrate meets the most critical requirements. This gave me a suggestion which I immediately acted upon. The most careful work in the laboratory seemed to show that if enough lime was added to absorb all of the free and a portion of the semi-combined, carbonic acid, then the sulfate of copper could be added with impunity and filtration immediately ensue, and no copper would be found in the filtered water. This did away with the objection to a water containing sulfate of copper.

But other objections were apparent. In the Bulletin the statements were made that one part of copper sulfate to 100,000 parts of water might be necessary to eliminate the typhoid and colon bacillus and that it took several hours for the death of the germs to occur after the copper was added. By experimenting I found this to be true. This would not allow its use in connection with mechanical filters at but very few points, probably none. To use 1 to

100,000 and treat all the water filtered would be too costly to make it a commercial proposition, aside from its being impossible to get the required time. It was clearly seen that this quantity of copper sulfate would have little effect in forming a coagulum and that practically as much would have to be expended for a coagulate as though no copper sulfate had been employed.

Again the laboratory was called upon. A coagulum of hydrate of copper was formed and deposited as a film on a small filter and then a water heavily contaminated with colon bacillus was passed through, with no copper being added to this water, at a rate approximating 100,000,000 gallons per acre per twenty-four hours. Owing to the small size of the apparatus and the difficulty of getting an accurate set of conditions, the results were not all that had been hoped, but they were distinctly encouraging. Later and more carefully planned and conducted experiments gave more promising results, but still complete elimination of the colon bacillus was not obtained.

But the experiment proved that the time required was not for the copper to remain in contact with the bacteria, but to *get* in contact. In other words, to be thoroughly disseminated through and reach every bacterium of these groups. It also proved that the hydrate or sub-carbonate of copper was possessed of high toxic properties.

The fact that the hydrate of copper was as efficacious as the sulfate gave us our idea of a practical sterilization of water. It was believed that if sulfate of iron could be manufactured and a small quantity of sulfate of copper incorporated with the iron that this could be made at a cost that would make the process a commercial and practical one. A quantity of sulfate of iron containing small percentages of sulfate of copper was therefore prepared to enable us to test the process in a practical way.

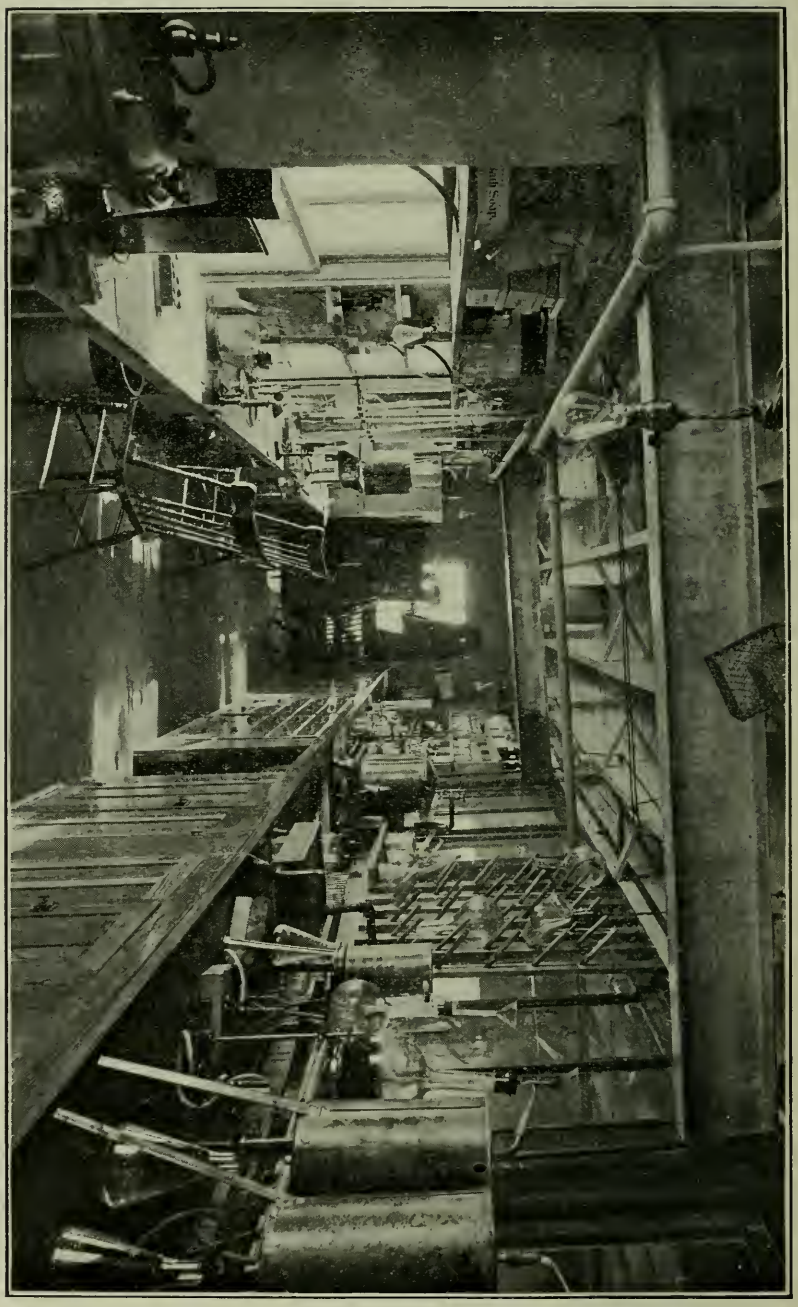
At this time the Anderson, Ind., plant was nearing completion. The authorities there were anxious to get the best results at the lowest cost. After considerable discussion it had been agreed to conduct a comparative test of alum and sulfate of iron as coagulants. It had been agreed that

a ten days' test should be made of each chemical. The test was to be made under my supervision. Professor Severance Burrage, Professor Sanitary Science of Purdue University, and Dr. S. C. Norris, city chemist, were engaged to check up the results. Although some of the straight sulfate of iron had already been shipped to Anderson, three further lots were forwarded. One contained 1 per cent. of sulfate of copper, another ½ per cent. and a third ¼ per cent. cent.

As this was a development of the work done by the Bureau of Plant Industry, it was decided to extend an invitation to the Bureau to take part in the test, and I accordingly went to Washington, and after informing Dr. George T. Moore of our plans, asked if they would accept the invitation to take part in the test. Dr. Moore immediately called Mr. Kellerman in and they informed me that they would be glad to have Mr. Kellerman come to Anderson, and if possible Dr. Moore would be there also.

The water to be filtered was that of the White River flowing through Anderson. During the time of the test the river was ice bound from Anderson to Muncie. Muncie is about twenty-five miles above Anderson. All the sewage from the former town enters the river and owing to the low temperature of the water and the fact that neither sunlight nor air could reach the water, owing to a heavy layer of ice over the entire stream, the conditions were ideal for a test of the value of the new product. The fact that a dilute sewage was to be handled led us to think the test a particularly trying one.

The filters were of concrete construction, twelve feet wide and thirty-six feet long at water level with a filtering area of 350 square feet, and a daily capacity of 1,000,000 gallons, each equipped with Weston controller. The controller was set so as to average 1,000,000 gallons per twenty-four hours for each filter. Four filters were equipped and two were yet to be completed. The city was using less than 2,000,000 gallons per day, so the sewer was tapped so as to permit the superfluous water to escape, and all four filters were operated under uniform conditions throughout the test, thus wasting over 2,000,000 gallons daily of filtered water. Two lime tanks and two iron



VIEW IN LABORATORY, ANDERSON FILTER PLANT.

tanks of concrete construction served to make up the solutions in. Lime was slaked in a slaking box and afterwards run into the lime tank and that filled with water. Iron sulfate was dissolved in a similar box and run into the iron solution tanks. Triplex rotary power pumps elevated the solutions to head tanks, from which a gravity discharge, through constant orifice plate, occurred. A uniform head in the head tank was maintained by means of an overflow pipe. The excess solution returned to the chemical solution tanks and gave an efficient stirring action to the solutions. This was supplemented by mechanical agitation apparatus which could be utilized if needed. By this means a constant and accurate application of the chemicals was assured.

The water was delivered to the filters by centrifugal pumps, with direct connection to high speed vertical engines, both in duplicate. Iron, alum and lime solutions were injected in the suctions of the pumps.

Right here I wish to call general attention to this feature. During the last year or so I have visited a dozen or more plants where they have tried to put lime water or milk of lime in the suctions of pumps, and in each and every case trouble has resulted. It is time for this thing to be stopped, and I hope no one present will ever attempt or permit any one else to attempt to put lime water or milk of lime into the suction of any pump, centrifugal or piston, in connection with a natural water. Any properly constructed pump will pump clear lime water or milk of lime indefinitely and no trouble result, but if a mixture of lime water and natural water be put through the same pump incrustation will occur and it will be only a matter of time till that pump goes out of commission. The mixture will pass through a main or closed conduit and manifest no tendency to build up or incrust beyond a certain point, which never causes trouble. Iron sulfate or alum solution may be delivered to the suction, if desired, as no harm will result. This was corrected later on at Anderson, both chemical solutions being delivered into the discharge from the centrifugals. During the time alum was used, it was dissolved and run into the tanks which were afterwards used for iron solution. Each tank held enough solution to run the plant twelve hours.

Previous to starting the test, it was agreed upon by the four analysts that the end to be obtained was a water free from *B. coli communis.* It was understood that enough alum should be used to attain this result if possible, and that enough iron containing copper should then be employed to bring about the same result. If a small use of alum should result in giving a water free from *B. coli*, then it would be necessary to so operate the filters as to effect lower percentage removals so that we could get conditions where it would be near a break.

The test started using one grain of alum per gallon of water filtered. The colon was found present in the filtrate and the alum was raised to two grains per gallon and then to three, but the *B. coli* did not drop out. A very poor coagulation resulted even from this amount of alum. No cause is known unless the large amount of chlorine and organic matter retarded the coagulation or induced a collodial suspension of the same. Lime used in connection with alum did not materially improve the coagulation and did decrease the amount of color removed. When sulfate of iron containing one per cent. of sulfate of copper was applied at the rate of 1½ grains per gallon, the colon bacillus dropped out immediately. Even when a one-half per cent. sulfate of copper-iron sulfate was employed and 1½ grains per gallon used, the same results obtained. When a one-fourth per cent. mixture was employed a break occurred and the colon appeared in the filtrate as it did when straight sulfate of iron was used. When we went back to one per cent. mixture it instantly dropped out on all four filters.

At no time was copper found in the filtrate even when 4½ grains of 1 per cent. mixture was used. Not even a trace could be found by concentrating large volumes of water. Ferrous iron could not be found in the filtrate though small quantities of ferric iron were present. This only amounted to about .02 or .03 parts per million.

The following chart will give a good idea of the results obtained.

EXPLANATION OF THE CHART.

From the 2nd to the 11th of February inclusive alum was used. From the 12th to the 23rd inclusive sulfate of iron was used. On the 22nd of the month the sulfate of iron used

contained no sulfate of copper. The amount of copper sulfate employed from day to day is indicated by the black line, plotted in above the *B. coli* results, starting on the 12th and ending on the 21st, beginning on the 23rd and ending the same day. From the morning of the 12th until 6 P. M., February

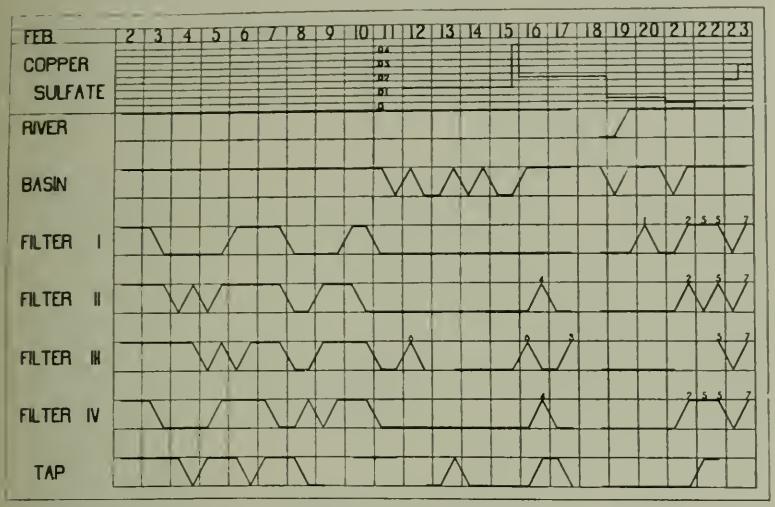


CHART SHOWING PRESENCE AND ABSENCE OF B. COLI COMMUNIS AND AMOUNT OF COPPER SULPHATE, IN GRAINS PER GALLON EMPLOYED.

15, .015 of a grain per gallon of sulfate of copper was used. From 6 P. M. until midnight of the 15th, .045 of a grain was used. From midnight of the 15th until midnight of the 18th, .0225 of a grain was used. From midnight of the 18th until midnight of the 20th, .0075 of a grain was used. During the 21st, .00375 of a grain was used. From midnight of the 22nd until noon of the 23rd, .0189 of a grain was used. From noon of the 23rd until midnight of the same day, .03 of a grain was employed.

Copper Sulfate.

.00375	g. p. g.	=	.064	p. p. m.	=	1	to 15,576,000
.0075	"	=	.128	"	=	1	" 7,788,000
.015	"	=	.256	"	=	1	" 3,894,000
.0189	"	=	.323	"	=	1	" 3,091,000
.0225	"	=	.428	"	=	1	" 2,336,000
.03	"	=	.513	"	=	1	" 1,947,000
.045	"	=	.770	"	=	1	" 1,298,000

g. p. g. = grains per gallon.
p. p. m. = parts per million.

It will be seen from a study of the chart that the colon bacillus was present in the river water in every sample taken, save two, during the twenty-two days test. In the ten days time during which alum was used, the colon bacillus was present in the settling basin in every sample taken, save one. As soon as the sulfate of iron containing copper sulfate began to be used the colon bacillus appears only periodically in the water coming from the settling basins. On February 22, when no copper was employed, it is shown to be present in both samples.

As will be seen, a series of small figures have been inserted at the points showing presence of colon in the filtered water after sulfate of iron containing copper sulfate began to be used. An explanation of these figures follow:

NOTE No. 1.—Filter No. 1 shows colon present on this occasion only .0075 of a grain per gallon of copper sulfate being employed. During this period the filters were running very irregularly owing to the fact that one of the settling basins was being filled and the probabilities are that the application of the chemical was irregular.

NOTE No. 2.—This appears on filters No. 1, 2 and 4. .00375 of a grain of sulfate of copper per gallon was employed. 1.5 grains of sulfate of iron, containing ¼ of 1 per cent. of sulfate of copper being used at this time. This is evidently too small a quantity to handle as badly a contaminated water as existed at Anderson.

NOTE No. 3.—This appears on filter No. 3. Previous to the time of taking this sample this filter was being used experimentally and the operation seriously interfered with. We expected colon to develop in this sample.

NOTE No. 4.—This appears in filters No. 2 and 4. From 6 P. M. until 12 P. M. of the 15th, 4.5 grains of sulfate of iron containing 1 per cent. of sulfate of copper was employed. When we left the laboratory at midnight, it was seen that this large amount of coagulant was going to cause trouble. We instructed the night man to reduce it to 2¼ grains. In attempting to do so he entirely closed the valve and no coagulant entered the water for several hours. This allowed contaminated water to pass the filters, and at the next washing

the contaminated water from the clear well again contaminated the filters, and near enough the time of sampling to show *B. coli* in two of the samples.

NOTE No. 5.—This appears on filters No. 1, 2, 3 and 4, during the 22nd of February, and is occasioned by sulfate of iron containing no sulfate of copper.

NOTE No. 6.—This appears on filter No. 3. A leak in the air pipe was discovered on the 11th and 16th of February, which permitted the unfiltered water to enter the filtered water without passing through the sand. Colon being present in the settling basin on both occasions, it was logical to expect to find it in filter No. 3 under these conditions.

NOTE No. 7.—This occurs in filters No. 1, 2, 3 and 4. Previous to taking these samples a ten gallon culture of *B. prodigiosus* had been injected into the water entering the settling basins and only a few seconds after the sulfate of iron was applied to the water. It has been ascertained by the Bureau of Plant Industry that such amounts of bouillon are sufficient to render the copper sulfate innocuous, thus explaining these four samples.

It will be seen that there is a break in the chart on the morning sample of the 18th, no samples being taken at this time. The centrifugal pumps were closed down to effect the removal of the incrustation caused by the application of lime to the suction of these pumps.

As is to be expected, the tap samples follow in a general way the composite of the filters, the curve being a little slower, as the tap samples were taken up town, and several hours would elapse before the water reached the tap.

It is seen from the above that with alum 20 samples were taken from the river, 20 from the settling basins and 80 from the filters. All the river samples contained *B. coli.* Out of the 20 settling basin samples taken 95 per cent. of the samples showed presence of *B. coli;* and out of the 80 taken from the filters, 47 of them or 59 per cent. contained *B. coli.*

Out of 23 samples from the river during the time sulfate of iron was employed, 21 showed *B. coli.* Two samples from the settling basin on February 22 contained *B. coli*, straight sulfate of iron being used. On the 21st of February ¼ per

cent. sulfate of copper mixture was employed and one of the two settling basin samples contained *B. coli.* During the rest of the time 1 per cent. or ½ per cent. mixture was employed and out of 19 samples taken from the settling basin 12 of them or 63 per cent. of the samples contained *coli;* thus showing nearly as good removal by sedimentation alone as was obtained by sedimentation and filtration, with alum. During this same period, if we exclude the accidental errors as explained by the notes, we have a complete or 100 per cent. removal by sedimentation and filtration using sulfate of iron containing not less than ½ per cent. of sulfate of copper. Using 1½ grains of iron sulfate containing ½ per cent. copper sulfate gave perfect filtration results, therefore no better could be obtained by using larger amounts.

From February 2 until 8 P. M. February 3, one grain of alum was used. From 8 P. M. of the 3rd, until 8 P. M. of the 4th, two grains of alum were used. From 8 A. M. of the 4th until 8 P. M. of the 9th three grains were used. From 8 P. M. of the 9th until 8 P. M. of the 10th two grains were employed. From 8 P. M. of the 10th until 6 P. M. of the 11th one and five-tenths grains of alum and two grains of lime were used. Thirteen runs were made with iron sulfate varying the amounts of iron, lime and copper.

Owing to minor defects in construction, the percentage of removal was low. While alum was used, the average number of bacteria in the river was 67,660, in the effluent of settling basins 26,856, and in the filtrate 5,539; showing a percentage removal of 91.81. During the time iron was used, the corresponding figures were 38,234—26,339—3,887, with a reduction of 89.80 per cent. The average amount of alum used was 2.5 grains per gallon and of iron sulfate 2.0 grains. The average cost for chemicals was $3.16 per million gallons for alum and $1.97 for iron sulfate and lime; a saving of $1.09 for the iron sulfate process. The cost was based on alum at $18.00 per ton, iron sulfate at $10.00 per ton and lime at $6.00 per ton. F. O. B. Anderson.

It will be seen that the alum exercised no selective tendency in removing or killing the pathogenic bacteria. It effected only a percentage reduction, and iron sulfate containing no sul-

fate of copper followed the same rule; but with the iron sulfate containing these small amounts of sulfate of copper, there is seen to be a selective action present. The amount of copper sulfate was large enough and the contact long enough to kill or remove the colon bacillus, even when only 1.5 grains of sulfate of iron containing ½ per cent. of copper per gallon was employed. This is equivalent to .0075 of a grain per gallon of sulfate of copper, .128 parts per million of sulfate of copper or one part of copper sulfate to 7,788,000 parts of water. Under the best practice using alum or straight sulfate of iron only a percentage removal could be obtained.

The argument has been made that the mechanical filter required care and skillful operation to produce high percentage removals. This has also been argued against the slow sand type of filters. It is known that there has been a great deal of truth in this argument. Some of the companies building filters have aimed to offset this argument by claiming that any man of average intelligence could operate *their* filters and produce results. I think this is a wrong position to take with any type of plant. Can you conceive of a large concern paying $50,000 or $100,000 for a piece of machinery and putting an inexperienced man in charge of it? Skilled attention will pay where as much depends on the successful operation of a plant as usually does on that of a filter plant.

But this heresy has become so firmly rooted that it is improbable that anything that I may say will totally uproot it. It is probable that many filter plants will continue to be operated as they have in the past. It has been seen that the percentage removals at Anderson were very low even with skilled attention. It is probable that other plants of first class construction and in perfect condition will, under less careful management produce equally as poor or even worse percentage results. It will be noted that with alum, as used at Anderson, no selective action was apparent. The alum removed a percentage of all bacteria present, having no apparent tendency to pick out and exterminate the dangerous bacteria. This, as far as we know, is universally true. It follows from this, that if there be 100,000 bacteria present in a water and it is filtered by any of the older processes, it is almost a certainty, even if

99.99 per cent. of all these be removed, that some of the pathogenics will slip through and may cause a higher typhoid rate than is desirable. With lower percentage removals the danger from this cause must increase very rapidly on a badly contaminated water.

The work at Anderson has proven that even on a water as heavily sewage laden as exists there and with only 89.80 per cent. removal, it is possible to completely eliminate all *B. coli* and assumedly all *B. typhi.* There is every reason to believe that this process will effect a larger percentage removal than would be obtained without the addition of the copper sulfate on a plant in first class condition. It is thought this marks an important advance in the art of filtration, and gives the mechanical filter an important advantage over any simple percentage removal process.

SOME EXPERIMENTS WITH COPPER SULPHATE.

By James M. Caird.

During the past two years several reservoirs containing algae growths were treated with copper sulphate under my directions. The amount of copper sulphate was applied to meet the different conditions; the quantity used varying from 1 part in 10,000,000 to 1 part in 1,000,000 parts of water.

In all cases 24 hours after the treatment, 1,000 c. cm. of the treated water being evaporated to 100 c. cm. were tested for copper. The potassium ferro-cyanide test was used.

When a solution of potassium ferro-cyanide $K_4Fe\ Cy_6$ (yellow prussate of potash) is added to a solution containing cop-copper, a chocolate-colored precipitate of ferro-cyanide of copper, $Cu_2Fe\ Cy_6$, will immediately form.

Samples of water taken from reservoirs 24 hours after the copper treatement and tested by the evaporation method gave negative results. The reason for this is readily seen, as the copper is absorbed by the vegetable matter and settles to the bottom of the reservoirs.

As considerable time is consumed in evaporating 1,000 c. cm. of water, and in some cases it being impossible to discontinue the use of a reservoir for any great length of time, I have resorted to the use of Nessler tubes (same as used in the determination of color) for the copper test with good success.

In making the test by this method, it is necessary to take a sample of the water before the copper sulphate is applied. This sample is used as a standard.

When using this method for the copper test, a solution of potassium ferro-cyanide is added to the raw and treated waters after they are in the Nessler tubes. If any copper is present it can be easily detected by an experienced eye.

As the potassium ferro-cyanide solution is very yellow, it is absolutely necessary that the same quantity of the solution be added to both the raw and treated waters.

The cyanide solution being the heavier, it is only necessary to add it to the water in the Nessler tubes as the mixing will readily occur; the comparisons of the colors can be made within two minutes after the solutions are mixed.

Laboratory tests show that 1 part of copper sulphate in 10,000,000 parts of water can be easily detected by this method.

The solution of potassium ferro-cyanide used was made by dissolving 20 gms. of the salt in 1 liter of distilled water; 2 c. cm. of this solution were used as an indicator for every 50 c. cm. of water examined.

Table showing proportion of copper sulphate in water, color and the intensity of the cyanide reaction:

Copper sulphate 1 in	Color	Test reaction	Copper sulphate 1 in	Color	Test reaction
10,000,000	35	faint	3,000,000	28	r-d.*
9,000,000	35	"	2,000,000	27	"
8,000,000	35	"	1,000,000	30	pronounced.
7,000,000	35	"	750,000	36	"
6,000,000	35	"	500,000	38	v-p.†
5,000,000	35	"	250,000	40	"
4,000,000	33	r-d*	100,000	45	"

No change could be observed in the turbidity of the samples after standing 36 hours.

The water used during these experiments was taken from the laboratory tap, and contained the following in parts per million.

Color 35.

Alkalinity	48	Hardness	55.95
Total solids	116	Loss on ignition	54.00

After the samples were taken they were allowed to stand in the laboratory 24 hours before the copper sulphate was added. The reason for this was that the water would then be about summer temperature.

The color of the water was reduced 22.9 per cent. when the copper sulphate was used at the rate of 1 part in 1,000,000. When the copper sulphate was used in stronger proportions the color increased. This increase was undoubtedly caused by the ferrous sulphate in the copper sulphate becoming oxidized by the dissolved oxygen of the water.

During these experiments a commercial copper sulphate was used which contained: Cu-25.45%—SO_4-37.68%—H_2O-33.94—Fe-trace.

*r-d, readily detected. †v-p, very pronounced.

When the copper sulphate was applied at the rate of 1 part in 1,000,000 the alkalinity (erythrosin method) was reduced 3 parts per million, while the hardness (soap method) was increased 0.36 parts per million. The increase in hardness was so slight that it can be disregarded.

Any reduction in the alkalinity might be a very serious matter, especially if it was low in the water to be treated, and the water was to be filtered by the mechanical process.

If such a deficiency in the alkalinity should exist it can be easily overcome by the addition of a little lime or soda ash.

Water containing copper sulphate (1 part in 1,000,000) filtered through ordinary filter paper gave the copper reaction.

Water containing copper sulphate (1 part in 1,000,000) to which sulphate of alumina had been added at the rate of 1 grain per gallon, did not give the copper reaction after being filtered through filter paper.

The same solution when tested without filtration gave the copper reaction, which proves that the copper had been absorbed by the aluminum hydrate.

This absorption is very important as it shows that a water which has been treated with copper sulphate and is to be filtered by the mechanical filters will yield a filtrate free from copper if enough sulphate of alumina is used.

In every instance where copper sulphate was used under my directions, only one treatment was necessary.

Results of all treatments have been satisfactory.

Since doing the original work which I reported in my paper I have made a series of experiments using sulphate of iron and lime as a coagulant and find that the ferrous hydrate precipitate will absorb the copper sulphate the same as the aluminum hydrate.

I also find that the addition of lime will cause the copper to be precipitated.

Waters which have been treated with copper sulphate and are to be filtered by the American Process, where ferrous sulphate and lime are used for a coagulant, will yield a filtrate free from copper.

If the water is to be filtered by the English System all that

is necessary to prevent the copper appearing in the filtrate is to add a small quantity of lime.

Potassium ferro cyanide when added to a solution of ferric salts will produce a dark blue precipitate of $K_4(Fe\ Cy_6)_3$—"Prussian Blue."

When the iron is in the ferrous state it will give a light blue precipitate of $FeK_2(FeCy_6)$.

As nearly all waters contain iron in some form, the concentration of the water by evaporation is a serious bar to a successful cyanide test for copper.

When the water is concentrated so that the iron is present at the rate of 3 parts per 1,000,000 and the copper sulphate 1 part in 500,000 the addition of the potassium ferro cyanide solution will cause a blue precipitate which will completely cover the chocolate or copper precipitate so that the test will be negative.

I wish to show by these experiments:—

First.—That 1 part of copper sulphate in 10,000,000 parts of water can be detected.

Second.—That copper sulphate when used in comparatively strong doses will slightly reduce the color of the water.

Third.—That copper sulphate will reduce the alkalinity and increase the hardness of water.

Fourth.—That water to be filtered by the American Process where alumina or iron and lime is used as a coagulant will be free from copper if the filters are properly operated.

Fifth.—That filtration without the addition of a coagulant does not remove the copper.

Sixth.—That the addition of lime will precipitate the copper.

Seventh.—That when iron is present it tends to interfere with the cyanide test for copper.

DISCUSSION.

Mr. Gwinn: I am very much interested in these valuable papers. I would like to ask Mr. Brown what period of time there was for sedimentation?

Mr. Brown: We had a double period of two hours, or four hours. When we were using only one settling basin, the period was two hours; when using both basins it was four hours.

Dr. Mason: A good many points have been brought out in these papers that have been exceedingly interesting, and are certainly new. I feel impelled to ask one or two questions with reference to that chart and what was said in connection with it.

I notice that while running on alum the bacillus coli communis is uniformly present in filtrate. That to me seems odd for this reason: I rather question if those who have had a large amount of experience with filters of the American type would care to admit that even in a fairly polluted water the bacillus coli communis will always be present in the filtrate. I cannot help but think that something must have gone wrong. In dealing with the Hudson River water at Albany, a very seriously polluted water, the purification is conducted upon the English filter bed plan. The water contains in the raw state many thousand bacteria of all kinds and descriptions. The appearance of the bacillus coli communis in the filtrate is rare. Now, if that result is being accomplished by the English filter bed, it seems, by comparison, to me that the American system as here illustrated is shown to be much inferior, because there you have coli always in the filtrate. I cannot help feeling that something is the matter in this instance.

Again, I should like to ask whether the thought has occurred to the reader of the paper that possibly the beneficial results produced by the mixed metallic sulphates have been because of a different physical state of the coagulant? Everybody who has had any experience in running a mechanical plant knows that if you have two plants in different parts of the country practically alike, and running on waters presumably similar, you may run the water through one plant and obtain an excellent result; while in the other case you may have to record more or less of a failure. Why this is so it is pretty

hard to say, although we know that physically the coagulation is distinctly different in some instances from what it is in others. Is it possible that the coagulation when the mixed sulphates are used, as described by the reader, differs physically from that produced by the alum, and because of that difference the different result has been produced?

Now with reference to another point. Note was made during the paper that the presence of proteid material would interfere with the toxic character of the copper present. Of course we must bear in mind that proteid material may often at first drift into water having sewage in solution, and we must be prepared for differences in results due to the interference with the toxic action of copper in consequence thereof.

Again, let us inquire as to the source of the typhoid germs with which the experiments were undertaken. Were they of laboratory growth, weakened by generations of "storage," or were they recently from the typhoid subject and consequently vigorous? As Jackson has pointed out, the former are vastly more easy to kill by copper sulphate.

Referring for a moment to the second paper, and to the statement which was made with reference to the interference of iron because of the formation of Prussian blue, I will say that what little experience I have had with reference to the detection of copper in weak solutions, bids me to rather prefer the dusky tint produced by ammonium sulphide. I think I can do as well reading differences in that duskiness in a tube as I can reading differences in the chocolate tint produced by the potassium ferro-cyanid. Of course in the event of iron being present it will be necessary to acidulate the water slightly.

Now if I may be spared a little further time, I should like to say to you with reference to the general question of the use of copper for the improvement of the water, first from the algæ side, second from the bacteriological point of view. Our thanks are unquestionably due to the Department of Agriculture, and to Dr. Moore in particular, for bringing forward so considerable a means as he has given us for the prevention of taste and smell; and I feel that we should gladly accept what he has brought to our attention, and attack

the algæ which produces such disagreeable results by the use of a solution of copper sulphate.

As to the destruction of pathogenic organisms, is that a very different proposition? From my point of view it certainly is. Let me ask your attention to this line of thought. You have present in your reservoir, let us suppose, contamination from growths of algæ. You introduce copper in the small amounts started, of one part to fifteen millions, or one part to ten million, you destroy the objectionable item, and as a result your people are satisfied. Such "dosing" of the reservoir is but semi-occasional. But if you are intending to destroy typhoid germs, you must repeat the dose every day in the year. Therefore is it not well worth our time to consider this suggestion? If your intention is to destroy algæ you are obliged to act but seldom. It may be that your reservoir will never need another doctoring, for you certainly are not going to doctor it until something is the matter with its water; but if you are venturing into the business of destroying typhoid organisms, you know very well that you will have to repeat to-morrow what you have done to-day. You will be forced to apply your dose three hundred and sixty five days in the year. In other words, it means continual disinfection.

Are you willing to go back to your constituents and say, "Gentlemen, we are going to disinfect your water supply." The chances, I fear, would be against their liking the proposition. Of course you might be able to persuade them that it is all right; but I feel that the whole situation to-day is just a little bit young at present. Let us hope that it will grow.

Gentlemen, I fear I have taken up a great deal of your time, but I think that my case rests here, viz:—removing algæ is occasional; but the removal of disease germs must be continuous. The dose for algæ is only for the present moment, while that for bacillus typhosus must be for all time.

Mr. Maignen: I would like to say one or two words in discussion of the paper just read. The last speaker asked why should a slow sand filter give better results than a mechanical filter, adding that those interested in mechanical filtration

must take off their coats and set to work to produce better results.

In this respect I should like to observe that the cause of the difference lies in the fact that mechanical filters are disturbed very frequently. Experiments were made in Egypt with mechanical filters, and it was shown clearly that for half an hour after cleaning the (mechanical) filter, the filtered water contained more bacteria than the unfiltered water. This could be explained by the fact that in the washing operation the sand is mixed up, the sand of the upper layer changing place with that of the bottom layer, and the different strata thus becoming thoroughly intermingled. The bacteria which were originally retained on the surface of the sand are, in part, washed out and in part retained on the grains of sand themselves; and when filtration is resumed, the bacteria left in the sand bed pass out with the freshly filtered water.

In the slow sand filters, on the contrary, the surface of the sand alone is disturbed. The mass of the sand bed is not interfered with in any way; and moreover, the cleaning operation is not performed with as much frequency, slow sand filters generally running for a month without disturbance; whereas mechanical filters have to be cleaned once, and sometimes two or three times a day.

In connection with the presence of bacteria in the filtering medium itself, I would state that a few years ago before the American Society of Civil Engineers, I had occasion to present a paper in which I spoke of what is known as "ripening" filters. It is sometimes stated that sand filters become "ripe" when the grains of sand are covered with bacteria extracted from the first water going through, the accumulation of which bacteria is supposed to constitute what is called a "schmutzdecke." It is even stated that most of the bacteria thus retained on the sand are harmless and destroy the harmful ones.

The idea that filters are "ripened" by the addition of bacteria therein is an error, in my opinion. Granular filters are "ripe" when they are deprived of the bacteria which were in or on the granular filtering materials before use. It is

well known that new filters do not give good bacterial results. It usually takes a month or more before the filtrate is satisfactory; but the bacteria found in the unsatisfactory filtered water do not come from the applied water. They come from the filtering materials themselves. This conclusion was demonstrated by experiments which I made some few years ago and described in the paper referred to above as read before the American Society of Civil Engineers.

I filled three filters with sand, some washed and some unwashed, and filled three other filters with charcoal, applying to all of these filters filtered water which was practically sterile, containing only eight, ten, fifteen or twenty bacteria per cubic centimeter. During the first few days the filtered water contained 200, 300, or 400 bacteria per c. c., and the quantity increased until on the fifteenth day the filtered water contained as much as 5,000 bacteria per c. c. I continued applying the same practically sterile water, and found that it required another fortnight for the filtered water to contain no more bacteria than the applied water; the quantity diminishing daily from 5,000 on the fifteenth day to 8 or 10 on the thirtieth. Then I applied the tap water during six months afterward, day after day; this applied water containing tens of thousands of bacteria and a great many liquefying bacteria, the filtrate during the whole of the six months, from the six filters, never contained more than 20 bacteria per c. c., and never as much as one liquefier. It is evident that the large number of bacteria found in the filtered water during the first month were not water bacteria, as none, or practically none had been introduced. They came essentially from the dust of the air, which was on the surface and in the pores of the filtering materials.

You will all remember the beautiful experiments of Tyndall with the air dust, how he demonstrated that the dry spores of the air required a period of incubation in water, in order to develop into full grown, or adult bacteria. It is therefore presumable that the air spores which were in the sand itself, or the charcoal, were gradually incubated by the filtering water, to be carried out with the water from the under strata of filtering materials without any straining

action such as takes place on the surface of the sand when the schmutzdecke is formed. These bacteria may be called "constitutional" bacteria, because they are a component part of the sand or charcoal before use.

I wish you to understand that the "ripening" of filters does not consist in populating the sand with water bacteria, but in freeing it from air germs by natural continued filtration. It has been believed abroad and in this country, that it is sufficient to submit a filtering material to steam or dry heat to sterilize it. This is an error. Tyndall has shown that it is necessary to boil the water three times, allowing intervals to elapse, so that the dry spores are incubated by the first and second boilings and prepared for development into adults, in which condition they are easily destroyed by boiling, whilst the spores are not affected thereby. The presumed sterilization therefore of sand and charcoal by one single application of steam or dry heat is not realized. The intervention of the air bacteria during the ripening period of filters and at other times, makes the ordinary quantitative analysis very inconclusive, and I have arrived at the conviction that in analyzing the work of filters the research for coli bacilli is the only one which is reliable.

Previous to 1893, I discovered that the chemical purification by means of lime and soda, which I used for softening water, sterilized the water, and this without any excess of chemicals; thus leaving the water perfectly potable. This was confirmed by some eminent authorities, notably by Professor Ray-Lankester, of Oxford, England, and Dr. Burlureaux, of Paris.

My French friends had difficulty in understanding why their simple reagents killed the bacteria, as no poisoning or toxic substance was used in the operation. The only explanation that could be given was that the change of environment to which the bacteria were subjected did the sterilizing. In water thus treated there is a succession of chemical reactions which lasts two hours, during which time the bacteria are, as it were, bombarded by the various interchanges which take place between the acids and the bases and the result in abundant precipitates.

The action of copper is entirely different. Copper is certainly one of the most powerful antiseptics known. It seems to act upon the proteid matters by an invasion and change of the original organic substance. To convey to you an idea of this action, place under a microscope a drop of infusorial water, which you can obtain by placing flowers, leaves, hay, meat or other organic matter in water and allowing it to stand a few days. You then find a considerable number of different animalcules. Add a very light solution of potassium permanganate, so as to turn the water to the color of a light pink rose. If you watch the action of this reagent on the infusoria you will see the pink color gradually disappear in the field of the microscope, and the infusorians and bacteria themselves will have changed color; from a transparent gelatinous appearance they will now seem to be light yellow, and gradually will become darker, and ultimately brown. Copper acts somewhat in the same manner. It fixes the suspended organic matter and organisms. This is why the feature alluded to by the last speaker is to be guarded against, viz., the addition of gelatine or bouillon, as being likely to neutralize the action of copper on the bacteria when sterilizing water with copper, the copper uniting with the organic matter and being absorbed by it, and so that an extra quantity is required to act on the bacteria.

This action of the permanganate on organic and organized matter is exceedingly interesting; and this reminds me of the first lesson I learned in England thirty years ago in the analysis of water. When the water of a well was to be examined for pollution, we were advised to fill a quart glass-stoppered bottle with the water to be tried, and to add to it a very small quantity of potassium permanganate, just enough only to give the water the color of a very light pink rose. If the water is bad this pink rose color will immediately assume a dirty yellow appearance, or disappear altogether. If the pink color does not disappear at once, the pollution is less. You then wait until the next day, by which time, if there is no organic matter at all in the water, the pink color will not have disappeared. If it has disappeared, you will find at the bottom of the bottle a brown precipitate, which is exactly what you would see under the microscope if you made the experiment before alluded to. This

test is not absolutely reliable, because iron will also decompose potassium permanganate; but it is sufficiently indicative to warn of the presence of organic matter, or iron.

In the art of water purification there are two distinct principles which are presented, one by the slow sand filters, and the other by chemical treatment. By chemical treatment I do not mean the addition of alum or any other so-called coagulant, to help the action of the filter. I do mean, however, the action of a suitable reagent to effect a chemical purification such as that which is carried on in the softening of hard water, wherein objectionable matters are thrown out of solution without leaving any trace of the chemical in the water as in the case of the Clark's process, and in some cases leaving non-objectionable matters, such as sulphate of soda after treatment with carbonate of soda.

In other words, the chemical action ought to stand by itself. For instance, if a water has need of chemical purification, let it be treated in a tank and allowed to settle. When you cannot allow enough time for the settlement to be complete, use a filtering device. To purify the water is what is required, not to assist a filtering device, as is the case with the so-called mechanical filters in which the sand has to be so coarse as to be insufficient when the chemical purification is not complete. If the filtering sand is fine enough to clarify without a coagulant, the desired quantity of water is not obtained; and if the quantity of water is obtained, the quality is not unless the chemical reaction has been absolutely perfect and complete. If the chemical purification has been absolutely perfect and complete, then a cheese-cloth can do the filtration.

Mr. Brown: In reply to the next to the last speaker (Prof. Mason) I would like to explain that I think he is laboring under a misapprehension. The chart shows that the first three samples of filtered water, Filter No. 1, using alum, contained coli, and the next five samples did not contain them. Four samples did contain; four samples did not contain; and so on with all the filters, taking them in order. During the application of alum to the water, the settling basin contained B. coli all the time, with the exception of one sample. The filtered water frequently showed the presence of B. coli, but when

we got over on the application of copper we found that the curve of the settling basin using copper is approximately a composite of the filters using alum. If you were to make a composite of the filter curves during the use of alum, it would just about approximate the sedimentation curve in the use of copper. The fact that B. coli began to be absent in the settling basin samples as soon as sulphate of copper begins to be applied, shows that one of two things occurred—either the physical character of the coagulant was such as to carry down with it the bacillus coli communis, or an absolute destruction of this bacterium occurs. The character of the coagulant would have no bearing except inasmuch as it gives us a more rapid precipitation. I believe I make myself clear on that. The fact that the sedimentation efficiency, from a percentage standpoint, during the use of iron sulphate on this water was less than with alum, seems to indicate that the cause of the dropping of the B. coli communis is due to the copper employed and is not to be accounted for by the physical properties of the iron coagulate.

No reason is known why the sedimentation efficiency with iron and lime should be so low. It is the first instance that I have met with where that held true. The conditions were peculiar.

Now, in relation to the statement made that the filters were not producing high percentages, Prof. Mason is right, and the paper which I read specifically stated, that owing to minor defects of construction high percentages were not obtainable. Those defects were caused by too light a gravel layer on the bottom of the filter beds. The gravel was too light or the wash was too heavy, one or the other. When the wash was applied this gravel was lifted through the bed and formed cones, leaving spaces through which water filtered at a higher rate than it was doing through the other portions of the bed. That difficulty has since been corrected, and I am informed to-day that bacterial analyses taken from the Anderson filters are showing 98 per cent. reduction.

In relation to the albuminoid precipitation of copper, it has been ascertained by the Department at Washington, that whenever bouillon is used for cultures and sulphate of copper ap-

plied, the sulphate of copper is precipitated, coagulated and rendered innocuous. Just previous to the taking of the last sample, ten gallons of bouillon culture of bacillus prodigiosus were added to the water in less than an hour and a half's time. The amount of organic matter injected there was tremendously above what would normally occur in the water. In addition to that this water was already badly polluted. We were trying to ascertain whether there might be a growth in the beds, or washing out of the beds, to account for the low percentages, by applying bacillus prodigiosus and ascertaining the percentage removal of the bacillus prodigiosus.

The argument made in relation to the continuous use of copper should be considered. The fact is, if you are going to use mechanical filters you must use coagulants; you cannot get away from them. If a coagulant is furnished you which contains one per cent. of copper, you use that and use it exactly as you would if you had straight sulphate of iron containing no copper sulphate. There is no more labor involved. You will have to bring about the same conditions to remove the iron sulphate that you do to remove the copper sulphate; and if you effect the removal of iron sulphate you also remove your copper sulphate. In other words, if all the free carbonic acid is absorbed and a small portion of the semi-combined, you have established a condition by which both iron and copper salts can be removed. If you do not do that you will get yellow, dirty-looking water which your citizens will never accept. One safeguard of the process is the fact that if you do not get enough lime to bring about a proper reaction, the citizens will object to the color of the water. The most delicate tests that we were able to make by evaporating large quantities of the water, and picking up the residue by acids, failed to show a trace of the copper. We used the ferrocyanide test, picking up with acid after evaporation to dryness.

Secretary Diven: I must take issue with Mr. Maignen as to the inefficiency of new mechanical filters or of the same after washing. New filters should, of course, be prepared for use by first carefully sterilizing the sand and then allowing the filtered water to run to waste till the beds are thoroughly settled and compacted, and till the "schmutzdecke" or slime

coat is formed. This, according to my experience, takes a short time, only two or three hours at most.

After each washing, it might be well to go through this same process, but I have seldom found it necessary.

It has been my habit to have samples of water taken for bacterial test immediately after washing, and every few minutes, for perhaps an hour, for the purpose of comparison with the average work of the filters, and I have never found any great difference in the efficiency of the filters, when they were giving 99 per cent. removal on an average, the fresh washed filters would fall as low as 90 per cent., but would within an hour, be fully up to the standard again. If the first water introduced on the beds after washing, was allowed to run to waste through the re-wash pipe, no difference in efficiency was perceptible.

I think in the case cited by Mr. Maignen there must have been gross carelessness in the management of the filters.

I believe if Mr. Maignen had carefully prepared his experimental filters and sterilized the sand, as I think is done in all the mechanical filters before they are put in service, that he would have obtained very different results.

Mr. Alvord: One thing suggests itself to me, that is the impression is being created here from the chart on exhibition that no coli existed in the effluent at certain times. Perhaps Mr. Brown's language is exact both in his paper and in his discussion, but it seems to me that the impression received is not exact. It would be exact to say that no coli existed in the samples *which were analyzed*. Now the same criticism would hold true with the raw water diagram, but that does not give rise to such a dangerous impression as does the misapprehension in connection with the effluent statistics.

We must remember we are dealing, not with percentage removals of ordinary harmless water bacteria, but we are considering absolute removing of pathogenic bacteria, and I think it would be wise if we bear in mind that that chart does not indicate—at least to my mind—that the pathogenic bacteria are entirely removed.

Mr. Brown: I think that point is well made. The statement made in the paper was that in the samples taken we have found

no bacteria of that character. Of course, we could not say anything about the water which we did not actually sample: but in the samples taken we got those results.

Now I might add that this work has been carried on a little farther, and we are starting a test at Marietta of the same material on a little different type of filter. The first tests made at Marietta have borne out the results of the work on the chart. The coli bacillus is eliminated as far as our samples go, with one exception, the filter beds being yet green on that one sample, which might have been due to their not having been properly cleansed.

Mr. Gwinn: What did you say the cost was of the copper iron sulphate per ton?

Mr. Brown: The saving is $1.09 per million, average cost for chemicals being $3.16 per million for alum and $1.97 per million for iron sulphate and lime.

The cost per ton of copper-iron sulphate varies from $10 per ton to somewhat higher prices at points remote from place of manufacture. All prices are quoted delivered, freight prepaid, and the variation in price is caused by higher freight rates at remote points.

Mr. Maignen: This saving is for iron-copper and lime. What is it for iron and lime alone?

Mr. Brown: We cannot figure that because the material is made and sold as a mixture. The iron sulphate furnished contains one per cent. of sulphate of copper. We have had to use a new process for manufacturing sulphate of iron to enable us to put in one per cent. sulphate of copper. It was impossible to manufacture sulphate of iron and put in exactly one per cent. of sulphate of copper with any of the older processes. We have a large amount of waste acids and waste copper and iron sulphate, so it is only a matter of mixing them to produce this mixture by our improved process. One-fifth of a grain of caustic lime would precipitate one grain of sulphate of iron, but that is not the factor which we bear in mind.

Some difficulty has been experienced by some workers who have tried to use this process in the past in obtaining results. We think this is due to the fact that they do not clearly understand the principle on which we are working. If you put

enough caustic lime in water to absorb all of the free carbonic acid and a very small portion of the semi-combined, in other words, just carry it over the line, you get a mono carbonate alkalinity with which the sulphate of iron will react and form a coagulant. If you do not put in enough lime to do that, you will not get the result. In some cases we use as much as four grains of sulphate of iron and less than one-half a grain of caustic lime, because it is not necessary to use enough caustic lime to precipitate all the iron sulphate employed if there be enough lime normally present in the water to accomplish this. If the water reacts alkaline to phenolphtalein, within three minutes after the iron and lime has been added, you will get your coagulation if you have used enough iron.

Professor Caird: Speaking about that difference in cost, what does the increased cost in slaking lime amount to? It takes considerable time and attention to slake lime.

Mr. Brown: In answer to that I would say that only chemical cost has been considered in this article. We have not figured in the labor account; but the labor account in operating with sulphate of iron and lime is somewhat balanced by the fact that while you have to make up a lime solution once in twelve hours, as was done in Anderson, you may, if you want to, make your iron solution strong enough to run you 24, 48 or 72 hours per tank. Iron sulphate is so much more highly soluble in water than alum that you can make it up in a stronger solution if the apparatus used for applying it is exact enough to enable you to use a strong solution. At Marietta, Ohio, we are using twenty-four hour tanks; each man serving twelve hours will, therefore, make up one chemical tank. This need not actually take more than thirty minutes of his time and need not be all at one time. In a three or four million gallon plant you have to have a man around to attend to it, and he can attend to this work in practically as little time as he could if he only had to make up alum solutions, because he is not busy half his time anyway. If you had a plant where you had to filter thirty to one hundred million gallons, the question of labor would cut some figure, but in smaller plants it is not of the same moment.

Mr. Maignen: I understand the last speaker to say that he used one-fifth of a grain of caustic lime to one grain of sulphate of iron, is that right?

Mr. Brown: Yes, sir.

Mr. Maignen: When I visited the St. Louis plant I was informed the maximum quantity of lime used was nine grains and the maximum of iron three grains. That was considered a great improvement in St. Louis, namely, that they used three times as much lime as iron. I only mention this for information as to which of the two is right. The impression made by the author is rather disconcerting to many of the members here, I am sure. Until now it was said that sulphate of iron and lime used together were of some good; now these are said to be no good, and the only thing good is said to be sulphate of copper and iron mixed and used in conjunction with lime, and even these results are not absolutely perfect! This is unsatisfactory. It seems to me that the case has not been left very clear; may I ask information as to the difference between the St. Louis practice and the Anderson practice?

Mr. Brown: The St. Louis people wish to use an entirely different process from that which is being used at any other point in the country, save one. They are aiming to get results not by filtration but by sedimentation only. They have no filters. They are going farther than that. They wish to effect a softening and are using enough caustic lime to precipitate practically all the carbonates of lime and magnesia in addition to the iron sulphate they are using, and by this process are softening their water to the extent of several grains per gallon. For every grain of temporary hardness which they take out of the water, they must put in .56 of a grain of absolutely c.p. caustic lime. The river water at St. Louis contains some free carbonic acid and the lime used is not chemically pure by any means, hence larger quantities of lime are used than would theoretically be required.

Mr. Gwinn: In connection with the Quincy plant, will say that when I was connected with it, we made an iron solution by the sulphurous acid process, and in using this solution as a coagulant, we used an excess of lime which resulted in materially softening the water. I am not prepared to say that the

throwing down of the carbonate of lime in the water does, in itself, materially assist in the purifying of the water, although I understand that it has been demonstrated that such is the case. As I understand it, the precipitated lime is granular and does not have the adhesive or sticky qualities of hydrate of alumina. At Quincy we would get 97 per cent. to 99.3 per cent. reduction of the bacteria.

We had a peculiar state of affairs at Terre Haute last winter. Shortly after the river was frozen over, I noticed a woody taste in the filtered water when drawn from the faucets. The taste was noticeable for about one week when the weather moderated and a sudden rise in the river carried out the ice; after the ice went out the taste was no longer noticeable. About January 1st the river was again frozen, and in a short time we had a great many complaints about the woody taste in the filtered water. There were days when we would receive as many as 40 complaints from the consumers about the bad taste in the water.

Ordinarily we do not pump the river water through our settling basin, except when the water is turbid, but with the idea that aeration would eliminate the bad taste, we began pumping through the basin and connected an air compressor to the supply pipe leading to the basin, at the same time we were using about two grains of sulphate of alumina per gallon. The period of sedimentation averaging about five hours, and the surface of the basin through which the water flowed was 60 feet x 230 feet. The woody taste in the water, after it had passed through the basin, was not so pronounced as it was in the river, but was still bad enough to cause many complaints.

As most of you gentlemen know, the Department of Agriculture, through the Bureau of Plant Industry, has made a study of vegetable tastes and odors in public water supplies and has been very successful in the use of copper-sulphate in destroying algæ, it occurred to me that copper could be used advantageously in treatment of the Wabash River water, and on presenting the case to the Bureau of Plant Industry, Dr. Moore kindly sent his first assistant, Professor Karl Kellerman, to Terre Haute to make investigation. With the aid of a microscope, Professor Kellerman found asterionella, and gave it as

his opinion that this vegetable organism was responsible for the bad taste. Professor Kellerman suggested that it might be well to examine the water from the streams flowing into the Wabash, with the idea of locating the breeding place of the asterionella. As the weather was very cold and the streams frozen over, this would have been a difficult task. Professor Kellerman also suggested that we might use copper sulphate in very minute quantities in the settling basin and if the conditions for the experiment had been more favorable at that time, I think I should have done so.

I have been very much interested in what Mr. Brown has told us about the combination of iron and copper, and I shall make preparations so that we will be prepared to use this coagulant when we have further trouble from asterionella. They say that asterionella has an oily substance, something like the geranium, and that when the plant becomes broken that the oil is liberated and that it is this oil that gives the water the woody or fishy taste. Now, the question in my mind is whether the oil can be removed after it has been liberated from the plant. I would like very much to hear from Professor Mason on this subject.

Dr. Mason: I think in all probability you would not be able to remove that taste and smell after the oil had once been liberated. You will of course diminish it some, simply because a material of that kind can be acted upon by metallic salts to some extent; but I would not have any faith in removing the after-death taste. You see the action of the copper being of a tôxic character, you kill the objectionable organism, but you would get an after-death taste.

Mr. Milne: I would like to ask Professor Mason if the use of copper sulphate will prevent the growth of asterionella if you use it in quantities prior to their season of growth in the reservoir?

Dr. Mason: It stands without much doubt that if you destroy the seed previous to planting a turnip that you do not get the crop. You see if you have your asterionella killer, by no matter what, although there may be the food present, you do not get the growth. Of course you might have a small amount of growth due to the small amount of seeds still left; but the

small amount of growth will not produce an objectionable taste. I do not know that I could do better than refer you to that classic case of the asterionella outbreak in Brooklyn. You doubtless have read all about that. There you have the seed supplied by the Jamaica pond section of the water-works; you have the food supplied by the wells section of the water-works; you have sunlight supplied in the open reservoir. When they all three come together, you have your crop. The seed is always present in the Jamaica Pond and its waste sheets of water, but without the silica bearing well water being added, there is not silica enough present to produce a crop, as the fruit of the seed, soil and sunlight.

Mr. Leison: The method generally in vogue for testing the efficiency of filters, and the relative purity of the filtered water, seems to be open to some objections both in regard to the culture medium employed, and in the percentage method of indicating results.

While not prepared to go into a thorough discussion of this question at the present time the writer hopes to be able to make a report at some future meeting which may be of interest to those having the question of filtration before them, but it would seem opportune to call attention to some of the results of experiments conducted by our bacteriologist, Dr. Albert Robin, at the laboratory of the Water Department, at Wilmington, Delaware.

The ordinary gelatine and agar generally employed as a culture medium, give a fair conception of the general efficiency of the filters, and must naturally show a more or less fixed proportion between the raw water and the effluent, when the same medium is used on both, and when lactose agar is employed, and the plates developed anerobically at a high temperature, an approximation to the number of toxigenic bacteria may be reached, but even this method does not appear to be entirely satisfactory.

As it is known that the saprophytic organisms are in no way harmful, the desirable thing would seem to be a medium which would eliminate all the saprophytes, and confine the investigations to the pathogenic bacteria, only, and this has been our effort.

After a series of experiments with different restraining media the one which suggested itself as best adapted to the purpose of limiting the development to a few species—principally intestinal bacteria—was the bile salt medium consisting of

Agar	1.5 grains.
Sodium taurocholate	.5 "
Peptone	2.0
Water	100–

Plates are made with 1 c. c. of water and incubated at 38° C. for 18 hours.

There is reason to believe that the most important antiseptic agent in the gastro-intestinal tract is bile, which owes its antiseptic action to its salts, sodium and potassium taurocholate, and while the majority of bacteria in water, food and air are destroyed by the bile salts, the comparatively few species known as intestinal bacteria seem to be capable of resisting the effect of these salts. It is therefore reasonable to suppose that a culture medium containing bile salts will restrain the development of all but a few species of intestinal bacteria, or those possessing equal resistance.

Results covering a period as yet too short to prove conclusive or to be accepted as a record, would seem to corroborate this view.

Raw water containing from 1,000 to 50,000 bacteria per c. c. on agar, have shown from 10 to 2,500 on the bile salt agar, and the effluent from the experimental filter has shown extended periods of no bacteria, and not over 3 or 4 per c. c. when the filter was operating properly.

The method possesses the following advantages:—

1. It permits the results to be known in a shorter time,—18 hours,—thereby affording the means of a more rapid correction of any failure of a filter to deliver a safe and pure effluent.

2. It eliminates the error due to dilution, which is necessary when an extremely large number of bacteria have to be counted.

3. It determines in a more satisfactory manner the hygienic efficiency of the filter, by limiting the investigation to those species of bacteria which are most likely to prove detrimental to health.

In regard to the percentage method of indicating the efficiency of a filter, the result is, as is well known, frequently misleading. For instance the effluent containing 100 bacteria per c. c. may show a higher efficiency than one where the number in the effluent is 50, merely because in the former case the number of bacteria in the raw water was so greatly in excess—and yet in the latter case the result is safer, regardless of the number in the raw water. In combination with the suggested method of using restraining media, it would seem that in each case (or at least in certain cases) a standard might be fixed of the number which might be considered permissible in the filtered waters, and whenever this standard was exceeded, it would be advisable to investigate the cause. What that standard number should be could be only determined by experimental work, but it would be a very low number—probably from 2 to 6.

The fact that under the method described, the results are obtained within 18 hours, makes it possible to check the delivery of water which is not up to the standard, or which shows indication of any radical increase in the sewage organisms, before any great amount has reached the consumers, and permits of the investigation and correction of any trouble in any of the beds.

Our experiments will be continued along the lines indicated, and the writer hopes that the results may prove both interesting and beneficial to the cause of filtration.

FILTRATION OF WATER IN ITS RELATION TO THE HEALTH AND PROSPERITY OF A MUNICIPALITY.

F. B. Leopold.

The first notable epidemic of which I have a record in this country was at Plymouth, Pa., in 1885; a village of 8,000 inhabitants, 1,100 of whom were stricken with typhoid, resulting in 114 deaths. In 1895 Grand Forks, N. D., a village of about 6,000 population, had 1,500 to 2,000 cases (25 per cent. of her population) and about 200 deaths. I quote the following from a letter recently received from Dr. H. H. Healy, Secretary of the State Board of Health of North Dakota:

"Previous to the epidemic the city water supply was taken from the Red Lake river, which is a small, unnavigable stream. Twenty-four miles above Grand Forks, by air line, Crookston was situated, with a population at that time of about three thousand. During the summer of '94 they had a good many cases of typhoid fever at Crookston. Their main sewer passed under one of the railroad embankments just before emptying into the Red Lake river. Some time during the summer the embankment crushed in the sewer, shutting it off. The sewage then came to the surface, and formed a small stagnant pond held back by the embankment. This remained, I think, for about two months, continually increasing in amount. Just about the time that ice formed on the Red Lake river this sewer under the track was opened up and the dammed back pond of sewage was allowed to flow out rapidly underneath the ice. This was, of course, the time of year when the water in the river would be quite low, so that there was little chance for proper dilution and aeration. As a result, some two or three weeks after this sewage was opened, the young people of Grand Forks took sick by the dozens, then by the hundreds. The degree of virulency seemed to be unusually severe. I am unable to state the total number of cases, but there must have been between fifteen hundred and two thousand cases during the next three months. The total population at that

time was about six thousand. There were probably about two hundred deaths. The above statements are not accurate, but will give you an idea as nearly as I can of the epidemic. I may state that the following year Grand Forks *established a filtration system* after plan of the Lawrence filter in Massachusetts, which has given splendid satisfaction. *Typhoid fever*, originating in town, is *almost unknown.*"

In 1903 the whole country was shocked by the records of Ithaca, N. Y., and Butler, Pa., which have made the names of these two obscure towns familiar throughout the world. Ithaca, N. Y., with a population of 13,000, had 1,350 cases of fever and 78 deaths; resulting in Cornell University being deserted for a time, the importation of doctors and nurses to take care of the sick and dying, a pall of uncertainty and stagnation covering the whole city for months, and a cost in money incalculable. The epidemic was caused, as the investigation demonstrated, by a contaminated water supply, through drainage which was washed into the stream supplying water to the city. The Ithaca epidemic covered the period between January 11th and April 15th, 1903, and was distributed pretty well over the whole city. Mr. Geo. A. Soper, C. E., made a thorough investigation, of every phase of the situation, for the New York State Department of Health, covering the water supply for the city and Cornell University. While no cases were traced directly to the latter supply, it was shown to be in constant danger of contamination from vaults. The supply furnished the city, however, is taken from Six Mile creek, and on this creek, but a short distance from the intake, within the city limits, were found 17 vaults overhanging or close to and draining directly into it. Several cases of typhoid occurring in the few months previous to the epidemic were also located within the drainage area of this stream, and the heavy rains occurring a couple weeks before and washing all the accumulated filth into the creek were undoubtedly responsible for the havoc of the next three months. In this connection attention is called to one incident of this epidemic. In the course of the investigation a number of wells were examined and many condemned. At one point a local outbreak of some 70 cases occurred, with four or five deaths. This was traced directly to

the use of water from one of the wells not examined. An investigation showed that the sewer drain from a house containing a typhoid patient passed near this well, discharging partly into the ground through a defective joint and contaminating the well; thus illustrating the danger of wells in a populous district.

Both the Water Co. of Ithaca and the University began the construction of filtration works immediately, and completed them as rapidly as possible, but the damage had already been done and the city was waiting to count the cost. We will see later what this amounts to.

The next notable epidemic was that occurring at Butler, Pa., a city of 18,000 population, in which 1,348 persons were stricken within the short period of ninety days and 111 deaths occurred, as given in the report of the State Board of Health. The conditions here were somewhat different from those at Ithaca, inasmuch as precautions were already being taken to secure the fullest protection to the water supply, and the town was caught practically in the situation of a man putting a new roof on his domicile when an unexpected rainstorm comes. Butler had a splendid waterworks near completion. One of the storage dams had been washed away and a new one was being built. It had completed a filter plant and was putting in new pumping machinery. The destruction of the dam necessitated the use of a water known to be more or less polluted. Nevertheless, as long as the filter plant was operating there was no sign of danger. During October, however, on account of the changes in the pumping station, the filter was shut off at intervals to allow work to proceed on these changes; and immediately there appeared the epidemic.

Within ten days after the polluted water began to be pumped direct the physicians were overwhelmed with calls. By November 29th the disease was so widespread and serious that a public mass meeting was called and a relief committee organized. In order to meet the expense of the committee $25,000 was voluntarily subscribed and it was estimated that $75,000 would be needed. Nurses and physicians were procured from Pittsburg, Philadelphia and other places. The work at the station was rushed to completion at the earliest possible mo-

ment, but to December 17, 1903, there was a total of 1,270 cases reported, with 56 deaths.

In this case the infection was traced to the drainage from a miner's cabin in which there was typhoid fever. The drainage from this cabin was directly into a small branch, the flow from which entered into the stream from which the supply was taken, and at a point a few yards above the intake to station.

The value of the filter plant is so strongly emphasized here that I quote the conclusions of the State Board of Health (pages 47 and 48 of report issued by them on the "Butler Epidemic"):

"The conclusions to be drawn from a review of the facts as they have been found to exist are that, following the destruction of the Boydstown dam on August 28, water for distribution to the people of Butler was taken from the Connoquenessing creek through an emergency intake at the pumping station; an examination of the waters of this creek showed that it maintains a fairly constant evidence of pollution, and that at various periods the operation of the filter plant designed to remove such pollution was partially or entirely suspended, and that as a result of this polluted water being used for domestic purposes, 1,348 persons who so used it were stricken with typhoid fever between October 1, 1903, and January 29, 1904, with 111 fatalities.

"In comparison with other epidemics of typhoid fever which have occurred at different periods, Butler presents in point of numbers, one of the greatest epidemics in proportion to the population in the history of the world. The records in comparison with certain other epidemics being as follows:

Location.	Date.	Population.	Cases.	Deaths
Lausen, Switzerland	1872	780	144	...
Caterham, England	1879	5,800	352	21
Plymouth, Pa.	1885	8,000	1,104	114
Ithaca, N. Y.	1903	13,000	1,300	78
Butler, Pa.	1903 and 1904	18,000	1,348	111

"It will be noticed from these statistics that Pennsylvania, within the last score of years, has contributed two of the most serious epidemics of a *preventable* disease which have occurred in recent years.

"This epidemic illustrates the serious burden of responsibility which rests upon both municipal and private corporations engaged in supplying water for domestic uses, and at the same time demonstrates that the streams of our State even in comparatively remote sections are capable of receiving such serious contamination that they should become the objects of the most careful supervision on the part of local and State authorities.

"That such a distressing calamity could occur in a community which prided itself on the safeguards of storage and filtration which they had provided, naturally excites the greatest anxiety concerning those very numerous communities which have no such protection.

"The efforts which have been made to secure a pure water supply for Butler have been of a far more energetic character than the very great majority of our municipalities have made.

"While ample storage has been provided for raw water and competent filters have been installed, the Butler system yet lacks the storage facilities for filtered water which would safeguard the town in event of enforced suspension of filtration for a period greater than twenty-four hours.

"The *efficiency of filtration* as a means of purifying water has been *well illustrated* in this instance, for although the polluted water of the Connoquenessing creek was used from August 28 to November 15, typhoid fever did not occur until the operation of the filter plant was interrupted in October. No object lesson to be learned from the epidemic can be compared, however, with the necessity which has been shown to exist for the compulsory registration by physicians of contagious and infectious diseases occurring in rural districts."

While it is notable that the years 1903 and 1904 have been unusually prolific in the production of typhoid fever, it is also notable that the sources of the origin of local epidemics have been more carefully traced and definitely located in the contamination of the water supplies.

Columbus, the capital city of Ohio, during the first four months of 1904 suffered very severely. During January, February, March and April there were reported, according to Mr. E. A. Moriarty, Secretary of the Board of Health, 1,640 cases of typhoid, with 166 deaths. A very full report was made by

Prof. Eno, of the Ohio State University, in the "Engineering News" of February 11, 1904, from which extracts are taken:

"Columbus secures water from Scioto river and partially from wells. From the river the water is supposed to be drawn from a system of galleries located in the river and consisting of about 12,850 feet or over two miles of 42-inch C. I. and brick conduit. The wells consist of 32 driven and one large open well 25 feet in diameter. The efforts in this direction, however, have proven the absolute inadequacy of such supply—the necessity of using the water direct from the river remaining as strong as ever.

"The reports and examinations of this water for the last five years by the State Board of Health have shown a badly polluted water. The examination of 515 samples, '89 to '03, shows an average number of bacteria of 2,228 and a range of from 160 to 20,000 per C. C. Only 7 per cent. of these samples fall below 300 per C. C. and, as Mr. Horton says, indicate 'how undesirable and unsafe' the supply is.

"The average number of typhoid cases for the last five years has been about 480 per annum, with about 10 per cent. fatalities. With these constant warnings and continuous, unnecessary loss of life, it required the sweeping epidemic of January and February of this year to awaken Columbus to a realization of its responsibilities. During January there were reported 724 cases, and to February 7th, 319 cases of fever; a total of 1,083 cases, with a total, to that date, of 57 deaths."

As soon as the rapid increase in cases indicated unusual pollution of the water supply, a systematic search was made for the trouble. Samples were taken at various points along the river and on January 14th sewage was discovered emptying into "dry run," which flows into the Scioto river, discharging from a 20-inch sewer connected to the State Hospital for Insane. Samples were taken from this run and from the river above and below the mouth of it. That from above showed considerable pollution. The dry run sample was nearly as bad as the average Columbus sewage. The sample taken below, while it did not show as much pollution as it should, considering the discharge of dry run, Mr. E. V. Horton, State Bacteriologist, states this was undoubtedly due to the fact that the

place from which it was taken was partially shielded from this discharge; and while he does not in his report lay all the blame on the sewage of the hospital for the pollution found in the river, he states that now that further discharges from that institution are stopped, he hopes to see a notable decrease in the epidemic after the period of incubation of the disease effected by pollution has passed. In this expressed prediction he was proven correct by after results.

In the "Engineering News" of February 25th, 1904, is a communication from Mr. Allen Hazen stating that the conditions found on this investigation are identical with those found by him and reported in March, 1895, in which report attention was called to hospital sewer and to the fact that the Scioto river was unfit for use as a public supply without purification. Still, with this warning ten years ago, it required the actual fulfillment of it in a serious epidemic before the people were aroused to the point of action. Columbus will install a filtration plant within the next few months.

I now have in mind another municipality in which there are prevailing the same conditions. The authorities conducted an investigation under the auspices of one of the recognized water supply experts some thirteen years ago. The findings of this report were that the supply was unfit for use without purification. How much greater the necessity then after thirteen years, with the increased population and greater number of sources of pollution! The doctors of this community are a unit in voicing the need for better water. Still, when the matter was taken up by the authorities a year ago the press and the people made such an outcry over the proposed expense that it was dropped, and probably will be until the community is visited by some such scourge as Columbus experienced; the cost of which will several times exceed the cost of a filtration plant, and leave a heritage of grief and death that will not be effaced for generations.

Among the lesser outbreaks of typhoid which occurred during 1903 and 1904, in an epidemic form, though not of such severity as those before mentioned, may be given Leadville, Colo., with a population of 15,000, where in about thirty days there were reported 500 cases and 23 deaths (Report of C. E.

Cooper, M. D., Secretary Colorado State Board of Health).

Watertown, N. Y., with a population of 25,000, during January and February of 1904 had 582 cases of fever and 49 deaths (Report of City Clerk, Dec. 24, 1904).

An investigation and report made by Prof. O. H. Landreth developed the usual findings—contaminated supply. A *filtration plant* has *since* been *installed.*

Mt. Savage, Virginia, a small mountain village of about 2,000 inhabitants, according to press reports, had 125 cases of fever in a period of about thirty days, with several deaths. An investigation of the water supply, which was obtained from mountain springs, supposedly pure, developed the fact that there was pollution due to sewage drainage from a house in the vicinity.

Minneapolis, Minnesota ("Eng. News," March 3, 1904, F .H. Bass, C. E.): "In this city the normal typhoid rate had been for some time from 25 to 30 cases reported monthly, but in January, 1904, it suddenly jumped to 192 cases reported. An investigation demonstrated that the district mostly affected was supplied from station No. 2, and, further, that while the total number of bacteria in the water at the time of the examination was not high, 85 per cent. of them were Coli communis."

Minneapolis draws its supply from three stations; Nos. 1 and 2 being in the heart of the city and No. 3 about three miles above.

(Engineering News, Feb. 11, 1904, Rept. Mr. Geo. Bowers, C. E.)

Lowell, Mass., secures water from wells; the mains are connected to the private supply of the Merrimac Cotton Mills, pumping river water and controlled by check valves. July 18, 1903, a large fire in the mills caused flow of city water to their system. After the fire one of the valves did not work properly, allowing mill river water to enter city supply. In a few days cholera morbus appeared in epidemic form, followed later by typhoid fever. The trouble with the valve was soon located, however, and all connections cut off; but during the next sixty days there occurred 168 cases of typhoid fever and 9 deaths. During the same period in 1902 there were 15 cases with 6 fatalities; 1901, 13 cases, with one death; thus illustrating what great

harm can be done by a very small amount of contamination.

(ENGINEERING NEWS, Feb. 11, 1904, Rept. Mr. F. E. Field.)

Kittanning, Pa., number of cases from 1898 to 1903: 1898, 45; 1899, 20; 1900, 76; 1901, 47; 1902, 52; 1903, 131. In December, 1903, 73 cases; January, 1904, 19. Population about 5,000. At present the water supply is from Allegheny river. During the investigation both the State Board of Health and the City collected samples, in all cases indicating contamination; all but two samples positive in colon bacillus.

Wicksboro (a village with population of less than 1,000), Pa., located on the same river and deriving its supply from it. During the two months of December, 1903, and January, 1904, it had 28 cases of fever and two deaths.

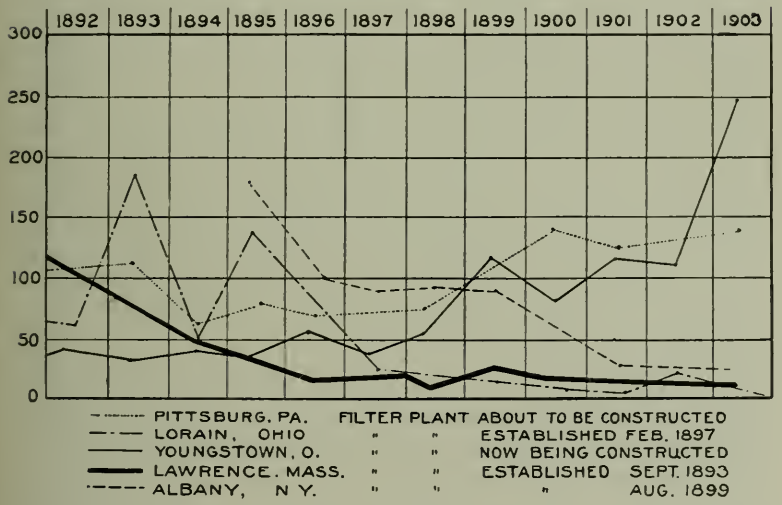
Ford City, Pa. Population, 3,000. On same river, four miles below Kittanning. Had 17 cases of fever during same two months.

During the same period that section of Pittsburg supplied with water from the Allegheny river reported a total of 866 cases. Here we can follow the river of death from point to point and calmly view the work of destruction as it proceeds.

(ENGINEERING NEWS, March 24, 1904, Rept. Mr. C. A. Brown.)

Lorain, Ohio. At this point we have a lesson somewhat analagous to Butler—in a milder form, however. In 1892 Lorain, a village of about 3,000, first established sewerage; and about the same time typhoid made its serious appearance. The death rate jumped from 43.5 per 100,000 (the average of the four previous years) to 183.3 in 1893, 48.8 in 1894, 131.6 in 1895, 83.3 in 1896. In 1897 a filter plant was established and the average for the next six years was reduced to 18.8; in 1901 as low as 5.5. For the first seven months of 1903 it was 0. In July, 1903, however, the filtration plant was found to be in serious need of repairs that necessitated a stoppage of the plant. It was, therefore, shut down July 16th and remained so until September 11th; and from that date to November 1st was intermittently out of use. The public was warned to boil drinking water in the meantime; but, in spite of this, typhoid appeared within three weeks and the death rate rose from nothing to 180 per 100,000, where it remained for the next four months, or until December 1st, by which time pure water was again

supplied, and December showed a reduction to 60. The actual number of cases for each month of 1903 was as follows: January, 3; February, 4; March, 1; April, 0; May, 0; June, 2; July, 3; August, 30; September, 67; October, 49; November, 5; and December, 2; August, September and October showing the effect of putting filters out of service. January and February of 1904 went back to zero. In this connection is given a chart, prepared by Mr. Brown, showing the relative typhoid rates in five cities, three supplied with filter plants and two without. Note the steady increase in typhoid with city's growth in those cities without plants and the uniform decrease of rates of those supplied with filters. Lawrence and Albany have the slow sand and Lorain the mechanical system. It may be noted that the other two cities are now engaged in the construction of plants.



As a further demonstration of the effect of water on the health of a community, the following from the report of Dr. A. R. Reynolds, Commissioner of Health of Chicago, showing the deaths and death rates for the four years before and four years after the opening of the drainage canal, is interesting:

Deaths from	4 Years 1896 to 1899	4 Years 1900 to 1903
Acute Intestinal Diseases	8,119	8,878
Rate per 1,000 population.....	16.41	12.44
Typhoid fever	2,266	2,235
Rate per 1,000 population.....	3.68	3.10

If the rate of the years 1896-1899, before the opening of the canal, had obtained during the last four years, there would have been 11,724 deaths from acute intestinal diseases and 2,629 from typhoid, or a total of 3,220 more than actually did occur. The money value of these lives, $16,100,000, is only one item to be placed to the credit of the drainage canal. From the standpoint of public health the drainage canal is the best investment Chicago ever made." Yet this canal cost over $30,000,000.

Also the following from the report of Dr. A. C. Abbott in ENGINEERING NEWS, February 11th, 1904, relative to the prevalence of typhoid fever in districts of Philadelphia supplied with filtered water and unfiltered water. Taking Roxborough district as one, Queen Lane district is 1.70 or, in other words, has 70 per cent. more typhoid; Belmont district is 2.15, or 115 per cent. more. The relative difference is striking in view of the short time during which *Roxborough* has been *supplied with filtered water*. Philadelphia is spending $17,000,000 on the construction of filtration works, and this vast amount has been practically lost in the last two years by reason of the lack of them. In the face of this showing who can say it is not a profitable investment?

Typhoid has also been unusually severe in Indianapolis, Cleveland, Buffalo, Philadelphia and Pittsburgh; although Pittsburgh has been rather notorious for years as a hotbed for typhoid infection. In fact, the death rate in the latter city is something appalling. The ENGINEERING NEWS of February 25, 1904, in commenting on the Pittsburgh situation, says: "A stronger indictment for neglect of the health and very life of its citizens could not be framed against any city than that furnished by the records of typhoid fever at Pittsburgh and Allegheny, Pennsylvania. * * * It is time for the press of the whole country to unite in a protest against the typhoid situation in these two cities. Self-destruction, bad as it is, might be

overlooked, but wholesale murder must be put down. * * * For the last fourteen years there have been some 30,000 cases of fever reported and over 4,200 deaths." The average death rate (as given in report published in the ENGINEERING NEWS) for five years, from 1893 to 1898, was 66.2 per 100,000; from 1898 to 1903 it was 128.6 per 100,000, a rate more than double.

It is not the writer's intention to attempt to do more than call attention to some of the more prominent instances of the effect of contaminated water supply on typhoid rates. In the foregoing were also given several very striking instances of the value of filtration works. I now give a summary of the degree of purification accomplished in a number of filtration plants established in other municipalities, which is worthy of the most careful study.

For comparative study I give here a copy of the degree of purification demanded by Mr. D. W. Mead in his specifications, which is practically identical with that demanded by all sanitary engineers.

"The purification obtained shall be such that in no case shall the average number of bacteria in the filtrate exceed one hundred per cubic centimeter, except where the number of bacteria in the applied water shall exceed 3,300 per cubic centimeter, in which event the average reduction of bacteria in the filtrate shall be at least ninety-seven per cent.

"Not more than five per cent. of the individual samples of the filtrate shall show more than 150 bacteria per c. c.; not more than five per cent. of the sample of the filtrate shall show an efficiency as low as 90 per cent. No trace of undecomposed coagulant shall be left in the filtrate, nor shall the filtrate show any increase in iron or alumina, or an alkalinity greater than in the unfiltered water. The filtrate shall show no acid reaction. The filtered water shall be clear, bright and practically free from color, turbidity or matter in suspension."

The accompanying plate, reproduced from photos of culture plates, taken during test of a plant at Oregon City, Oregon, gives a visual illustration of what a 98 per cent. bacterial reduction means.

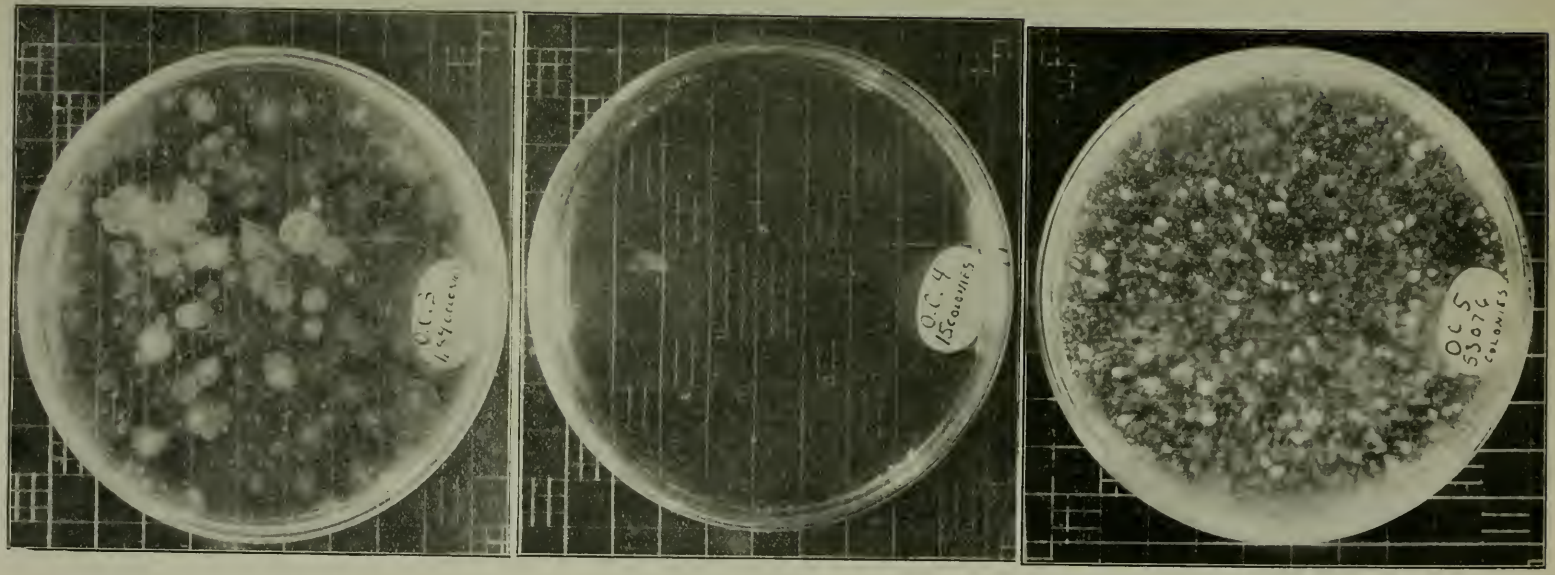
That results as given are secured by filtration works (and these tables are taken from reports of those in actual charge

Place and Observer	Month	Year	Raw Water Average No. Bacteria Per Cu. C.C.	Filtered Water Average No. Bacteria Per Cu. C.C.	Per cent. Removed
Elmira, N. Y.	June, July, Aug.	1898	2237	76	96.6
Reported by	Mar., Oct., Nov.	1899	6767	98	98.54
J. M. Caird,	Aug., Sept.	1900	547	17	96.9
Bacteriologist,	May, Aug., Sept.	1901	1394	17	98.78
Oct. 22, 1904.	May, Dec.	1902	10600	342	96.78
	June, Sept., Dec.	1903	4491	53	98.82
	June, Aug.	1904	647	8	98.77
			Average seven years		97.88
East Jersey Water	12 months	1903	3233	61	98.12
Co., Little Falls,	8 months	1904	1800	50	97.23
N. J. Reported by F. W. Green, Supt.			Average two years		97.68
Ithaca, N. Y.	3 months	1903	5173	27	99.48
E. M. Chamot,	9 months	1904	8332	74	99.11
Chemist in Charge.			Average two years		99.29
East Providence,	6 months	1899	596	7	98.83
R. I. Reported by	9 months	1900			97.08
Dr. G. T. Swarts,	9 months	1901			98.40
State Board of	9 months	1902			98.10
Health.	6 months	1903			98.93
			Average for five years		98.26
Lorain, Ohio,	6 months	1897			98.00
Dr. S. S. Cox,	1 month	1897			97.24
Health Officer.	January.	1904			99.13
Allen Hazen,	March	1904	52292	182	99.65
C. A. Brown.					
Louisiana, Mo.,	September	1899	9621	47	98.50
Prof. Amand Ravold, City Bacteriologist of St. Louis, Mo.					
Norristown, Pa.,	March	1900			98.72
Dr. M. P. Ravenal.					
Rensselaer, N. Y.,	April	1901			99.50
J. M. Caird.					
Vicksburg, Miss.,	July	1903			98.74
Prof. R. W. Jones.					
Elyria, Ohio,	February	1904			98.25
C. A. Brown.					
Oregon City, Oregon.		1904			98.00
Sunbury, Pa.,	February	1905	2100	47	97.7
Freeland Howe.					
Binghamton, N. Y.	9 months	1903	8457	45	99.47
	12 months	1904	7282	31	99.57
Danville, Ill.,	August	1904			97.71
C. A. Brown.					
Moline, Ill.,	April 26 to June 3	1904	27100	542	98.00
Prof. E. G. Smith, C. A. Brown.	September	1904			99.64
Norfolk, Va., Per	Oct. to Nov.	1899	356	12	96.00
J. J. McCormick, Prof. J. M. Caird.		1900			99.51
*Lawrence, Mass., Transactions	Oct., Nov. and Dec.	1902	11200	316	97.18
Am. So. C. E., 1903, Page 469.	Jan. to July	1903	8280	178	97.85
*Albany, N. Y., Transactions	Sept. to Dec.	1902	21125	193	99.1
Am. So. C. E., 1903, Page 469.	Jan. to July	1903	43613	459	98.95

*The plants at Lawrence and Albany, above cited, are of the English or slow sand type. The balance are of the mechanical type. Note the number of bacteria remaining in filtered water, in connection with percentage of removal; also how safely within the margin of requirements accepted by Sanitarians.

Culture Plates (Petri dishes) Showing Bacterial Growth from Three Samples of Same Water Supply

River Water Grown in Culture Madeia | Same Water After Filtration | Wash Water from Same Filters



1189 BACTERIA. | 15 BACTERIA. | 53076 BACTERIA.

The above plates were photographed during test at Oregon City, Ore., and convey an excellent idea of the value of mechanical Filtration.

of operations and entirely disinterested as to results) certainly establish the most intimate relations between filtration and the health of a community. That typhoid and kindred diseases are distributed through the medium of the water supply of a community, all authorities agree; and the heretofore described epidemics, with their investigations, absolutely demonstrate. If then we can eliminate 98 out of each 100 germs carried by the water, we reduce the chances of inoculation to 2 per cent. of what they would be in using the raw water. In other words, in one case we have 100 chances of being stricken; in the other, two chances. Should not this relative condition appeal to the senses of any intelligent community? Note the reduction at Ithaca—99.29 per cent., or less than one chance in one hundred. Can you think for a moment that had this filter plant been in operation at the time the pollution occurred, that Ithaca would have suffered that great catastrophe? The Lorain results during, before and after the repair of plant; and the Butler results during operation on polluted water and after cutting out for changes, fully bear this out. The chart showing the reduction in typhoid rates in several cities after the installation of filter plants furnishes further evidence.

I have heard arguments by physicians even against the installation of filter plants on the ground that it was impossible to get a guaranty of an absolutely pure water. Is this not the height of folly? Were these same doctors to be told that it would be useless to employ them unless they could guarantee an absolute cure, what would their answer be?

Believing that a sound relation between filtration of water and the health of a community has been shown, I will now proceed to the balance of the proposition, the relationship to its prosperity.

I submit the table as I have figured them on several of the epidemics.

It is interesting to note that all of these cities except Plymouth, Pa., and Leadville, Colo., either have now or are building filtration plants as a result of their typhoid epidemics; also the sums for which bonds might have been issued and redeemed in thirty years by the yearly loss represented in the loss of earning capacity of the deaths—in most cities several times

Cost of Typhoid Epidemics.

Place.	Population.	Number of deaths.	Number of cases.	Death loss at $3,000 each.	Cost of funerals at $30.	Cost of doctors' bills, nursing, etc., average 40 days whole number cases.	Cost of loss of wages, average 40 days each at $1.	Total direct loss to city.	Annual loss in earning power of deaths at $300 per annum.	Amount of 4% bond issue which annual death loss would retire in thirty years.
Plymouth, Pa., 1885.....	8,000	114	1,100	$342,000	$3,420	$38,500	$44,000	$427,920	$34,200	$570,000
Grand Forks, N. D., 1889....	6,000	200	1,500	600,000	6,000	52,500	60,000	718,500	60,000	1,000,000
						University Tuition	30,000			
Ithaca, N. Y., Jan. 15th to April 15th, 1903.....	13,000	82	1,350	246,000	2,460	47,250	54,000	379,360	24,600	410,000
Butler, Pa., Oct., 1902, to Jan., 1903	18,000	111	1,348	333,000	3,330	47,180	53,920	437,430	33,300	555,000
Columbus, O., 1904, 4 months.	140,000	166	1,640	498,000	4,980	57,400	65,600	625,980	49,800	830,000
Leadville, Colo., Dec. 20th, 1903, to Jan. 10th, 1904..	15,000	23	500	69,000	690	17,500	20,000	106,590	6,900	115,000
Watertown, N. Y., Jan., Feb., and March, 1904.....	25,000	44	582	132,000	1,320	20,370	23,280	176,970	13,200	220,000

STATISTICS OF TYPHOID AT PHILADELPHIA AND PITTSBURGH, 1902-1903.

Place.		Population.	Number of deaths.	Number of cases.	Death loss at $3,000 each.	Cost of funerals at $30.	Cost of doctors' bills, nursing, etc., average 40 days whole number cases.	Cost of loss of wages, average 40 days each at $1.	Total direct loss to city.	Annual loss in earning power of deaths at $300 per annum.	Amount of 4% bond issue which annual death loss would retire in thirty years.
Philadelphia, Pa.,	1903.....	1,350,000	588	5,006	$1,764,000	$17,640	$175,210	$200,240	$2,157090	$176,400	$2,960,000
	1903.....		957	8,701	2,871,000	28,710	304,535	348,040	3,552,285	287,100	4,700,000
Pittsburgh, Pa.,	1902.....	350,000	463	3,355	1,308,000	13,080	117,125	134,200	1,572,705	138,900	2,315,000
	1903.....		474	3,662	1,422,000	14,220	128,170	146,480	1,710,870	142,200	2,370,000

the amount necessary to build filtration works of the most elaborate character.

Following out this line of investigation, let me call your attention to a table of statistics of typhoid for the years 1902 and 1903 at Philadelphia and Pittsburgh:

On a basis of actual dead loss, this figures the enormous sum of $5,709,375, or $2,854,688 per annum, as a tribute to polluted water in Philadelphia. If we take again the amount of 4 per cent. bonds that might be issued annually and retired in thirty years by the annual loss in earning capacity of those slaughtered by this public indifference, we could provide an annual bond issue of $3,830,000, or in five years, the time required to complete the filtration works now building, the sum of $19,150,000, or more than enough to pay for them.

But this showing, bad as it is, is completely overshadowed by Pittsburgh. Here the death harvest for two years is equal to $3,283,585, or $1,641,790 per annum, with a population one-fourth as great. On the basis of 4 per cent. bonds issued, and death earnings, it is equivalent to $2,342,500 yearly. Five years ago Pittsburgh issued several million dollars in bonds for the purpose of providing pure water; while public officials have been wrangling as to how it should be spent a total loss equivalent to $11,712,000 has accumulated.

Five years more must elapse before a plant can be completed. At the same rate this is equivalent to $23,425,000, sufficient to build four or five plants of the most expensive kind. Still the people sit idly by and see their money and lives frittered away by the petty bickering of officials. Is it any wonder that the able editor of the Engineering News cries "wholesale murder" and calls on the daily press of the whole country to unite in a campaign against such a condition of affairs? Is it not a great wonder that the daily press, usually so keen to advocate matters beneficial to mankind, fails to see the great opportunity here presented, and is only at intervals aroused from lethargy by such occasional massacres as Ithaca, Butler and others?

Now in conclusion I desire to add but a few more words. According to a report printed in Fire and Water Engineering, Feb. 11, 1904, there were reported in the United States 500,000

cases of typhoid in 1903, with 50,000 deaths. Figuring the loss on the same basis as used in the previous tables, we have an annual tax of $186,500,000 or more than the cost of maintaining the army and navy combined; twenty-five per cent. more than the pension roll; an amount sufficient to build filter plants, at an average cost of $20,000 per million gallons capacity (which is liberal), capable of filtering 9,325,000,000 gallons of water daily, or 125 gallons per day for 74,500,000 people.

DISCUSSION.

Prof. Caird: I should like to add a little more on the typhoid fatality among users of well waters in the City of Elmira, N. Y. The situation in this city is rather peculiar. They have an excellent Jewell filter plant, which is doing good work, *i. e.*, reducing the bacteria 99 per cent. and over. The Health Department allows these wells to exist; they have something over a thousand of them.

A history of every case of typhoid fever has been kept by the Health Department for years. These records show the death rate among users of city water for four years before the filters were installed was 56.9 per 100,000; during the same period the death rate among users of well waters was 77.5 per 100,000.

The filter plant has been in operation for six years and the typhoid death rate among users of the city supply was 30.2 per 100,000, while during the same period the death rate among the users of well water was 64.5 per 100,000 population.

Since the filter plant has been in operation they had 25 cases of typhoid fever, with 5 deaths in one month. These cases were within two blocks and the people used the city supply. In no other section of the city were there any typhoid cases.

After making an investigation it was found that the same milkman was supplying all of those families and he had typhoid fever on his farm.

These cases and deaths were charged to the city supply.

A large number of the wells are in the low section of the city and when the river rises 10 to 18 feet, which is quite often, this section is flooded out, but as soon as the water

goes down the people start using the wells again.

At York, Pa., they also have a Jewell filter plant which uses alumina for a coagulant. Before this plant was installed the typhoid death rate was 75 per 100,000 population. Since this plant has been in operation the typhoid death rate has been reduced to less than 10 per 100,000 population.

The York condition is different from the Elmira because at York they have no wells.

Mr. Maignen: In Philadelphia in winter the average number of bacteria is 61,000 per c. c. in the river water. After remaining twenty-four hours in the reservoir the average number of bacteria is 91,000. In the summer months there is an average of about 6,000 bacteria per c. c. in the river water. After sojourning in the same reservoir it falls down to 3,000. The river and the reservoir are both covered with ice in the winter. I would like to have Prof. Mason's views as to what may be the cause of this difference.

Dr. Mason: The only explanation that I can hazard is that in the winter the bacteria from the sewage enjoy greater freedom from their natural enemies. In the summer the higher organisms destroy the bacteria.

Are your data for the average samples?

Mr. Maignen: A sample is taken every day for the whole year.

Dr. Mason: And that increases during the winter uniformly?

Mr. Maignen: Absolutely. The samples were taken by my bacteriologist on the one side and the city's bacteriologist on the other side. I would like at some future time if you will explain why they multiply in the winter and are diminished in the summer.

Mr. Rowe: I think it is possible that in warm weather they are so closely jammed that they smother. (Laughter.)

Mr. Gwinn: Perhaps it may be due to the fact that in the winter the river is lower than in the summer and the bacteria are present in larger quantities.

Prof. Caird: The sunlight in the summer may be re-

sponsible for the reduction of some of the bacteria.

Mr. Leopold: In regard to pollution by wells, I remember an instance that I would like to state. Some time ago I talked to a city official with regard to the installation of a filter plant. The reply was that they did not propose to put in a filter plant, they were going to put in a system of wells to get pure water. Underlying the soil was a stratum of loose sand and gravel and in the location where they were going to put in the wells they would get practically all the sub-surface drainage of the town. They quoted to me as an example the large number of wells that they had in town of beautiful clear cool water, and my argument to them was that that well water was probably more contaminated than the river water. They raved at it, so I asked them to have samples taken from three or four of the wells which they might select as the purest and best, and also samples of the river water to be taken at the same time. This was done, and the river water showed less contamination than any of the four samples they had selected as being the best in character of the well water.

SUNDRY NOTES ON DEEP-SEATED WATERS.

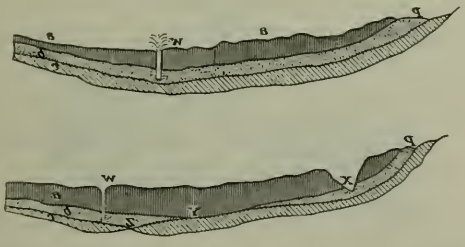
Dr. W. P. Mason.

The first point made by this speaker was illustrated by a slide showing driven wells in a group coupled up with main. Such wells tapped ground water. The speaker made the distinction between ground water and deep-seated water, the former being what might be termed local water, while the deep-seated water was described as that coming from a distance. The mere use of the term "deep-seated" does not

DRIVEN WELL PLANT, BROOKLYN, N. Y.

of necessity imply that the water must be tapped at a great distance below the surface of the earth, such water in fact delivering itself at the surface of the earth in the form of springs.

The method of boring deep springs was dwelt upon, and



CONDITIONS GOVERNING A FLOWING AND A DRY ARTESIAN WELL.

also the conditions under which deep-seated water might be found, as well as the conditions under which boring for such water would prove fruitless.

Notice was taken of the fact that deep water could not be secured in all localities; and special mention was made of economizing deep water and not pumping it beyond a reasonable limit, for the reason that in volume it is not inexhaustible.

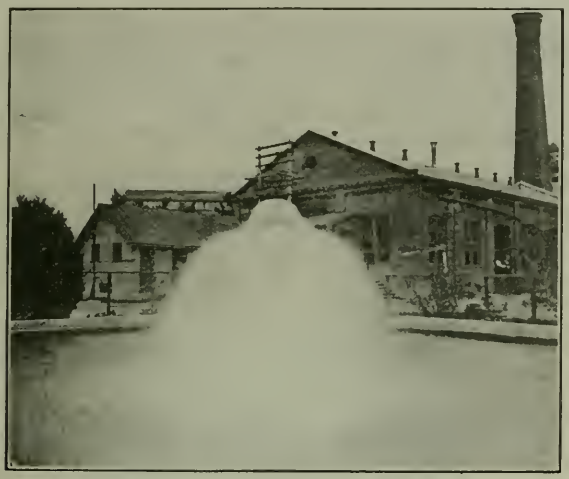
DEEP SPRING SUPPLYING ORLEANS, FRANCE.

Reference was then made to the London (England) wells, and the excessive use which had been made of them

ARTESIAN WELL AT WOONSOCKET, S. D.

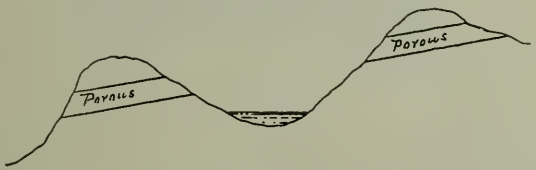
very greatly to the depletion of the deep water of that region. Illustrations of well known deep wells were given,

notably that at Woonsocket, South Dakota, where the well, which is 750 feet in depth, shoots a seven inch stream to the height of 80 feet in the air, the pressure of the water being 140 pounds to the square inch.



ARTESIAN WELL AT JACKSONVILLE, FLA.

The Jacksonville supply was shown, it being of artesian origin; and its probable relation to a sea spring on the East Coast of Florida was commented upon. Reference was made to the spring water supplies of sundry French cities, notably the Orleans supply, of which a slide was shown.



Illustrating a "contributing" Water-shed.

The general outline of the coast of the Italian Reviera at San Remo was given, showing, as it does, opportunity for deep well exploration in the immediate vicinity of the Mediterranean Sea.

Some time was devoted to a description of the water supply of Copenhagen, coming, as it does, from deep wells in the vicinity of the city; and a slide was shown upon which contour lines were drawn giving the depression in the subterranean water surface caused by pumping from the wells in question.

Contamination of deep water was touched upon, and the necessity of avoiding the use of sink holes for sewerage disposal in sections where deep water is to be utilized for potable purposes.

Reference was made to the relation between the spring of Lalou and the river Doub; the connection between the two having been established by the detection of absinthe in

SEA MILL AT CEPHALONIA SHOWING TAIL-RACE.

the spring some days after the destruction of an absinthe factory on the river.

A slide was given showing an ideal section of what was termed a "contributing water-shed;" such shed being peculiar in that water falling as rain thereupon is passed by subterranean channels through the intervening ridge and appears and is collected upon the neighboring water-shed.

The final slides given illustrated the peculiar sea mills of

the Island of Cephalonia; such mills having been constructed in 1835 and run during the intervening years; the power being derived from an undershot wheel driven by sea water which runs in from the bay, and which, after driving the wheel, disappears into the ground a short distance from the shore. A question frequently raised has been, what becomes of the water after its disappearance from the tail-race, the level of such tail-race being ten feet below the level of the bay? One explanation given is, that possibly it furnished the feed water for the line of vol-

SEA MILL AT CEPHALONIA.

canoes on the West Italian coast, and consequently was sent again to the surface as steam; another theory, which originated with Crosby, being that the water descended to great depths into some volcano vent, was heated at the bottom to again ascend as hot water, being specifically lighter, by way of another vent, and was delivered at the bottom of the sea.

STEAM TURBINES FOR WATER WORKS.

By Dabney H. Maury, Consulting Engineer, Peoria, Ill.

The Steam Turbine is so admirably adapted for use in connection with electric generators; the market for it in that field is so great, and the development of the modern centrifugal or turbine pump has been so recent, that one might naturally expect to find very little done so far in the way of building steam turbines for Water Works.

This paper will attempt, after giving a brief description of the structural differences in the three principal types of steam turbine now built in this country, to show, from the water-works Engineer's standpoint, the commercial state of the art of steam turbine and pump construction.

A Turbine has been recently defined as "a machine in which a rotary motion is obtained by the gradual change of momentum of a fluid."

In the diagrammatic illustration of a Turbine, shown in Plate I, the arrows 1 and 2 show the direction of flow of the fluid into, through, and out of, the passages P, between the vanes V. The change in the momentum of the fluid, by the change in the direction of its flow, and by the absorption of part of its velocity, results in imparting to the turbine a rotary motion in the direction of the arrow 3.

Turbines may be classed as either Radial Flow, Parallel Flow or Mixed Flow Turbines, according to the general direction in which the fluid travels through the passages between the vanes. Radial Flow may be either inward or outward. The Turbine just shown would be an Inward Radial Flow Turbine.

The DeLaval, Westinghouse and Curtis types are all examples of Parallel Flow Turbines.

Some of the large number of other Steam Turbines invented either here or abroad combine an inward or an outward radial flow with a flow parallel to the axis of the machine, and may therefore be classed as Mixed Flow Turbines.

Mr. Robert M. Neilson, in his recent book, "The Steam Turbine," says:*

*"The Steam Turbine, by Robert M. Neilson, Longmans, Green & Co."

"The action of the steam turbine depends upon the conversion of the heat energy of the steam into kinetic energy, and then in the transference of this kinetic energy from the steam to the rotating parts of the turbine. The latter part of the action is thus in principle much the same as that of the water turbine; but the former part has no parallel in the hydraulic

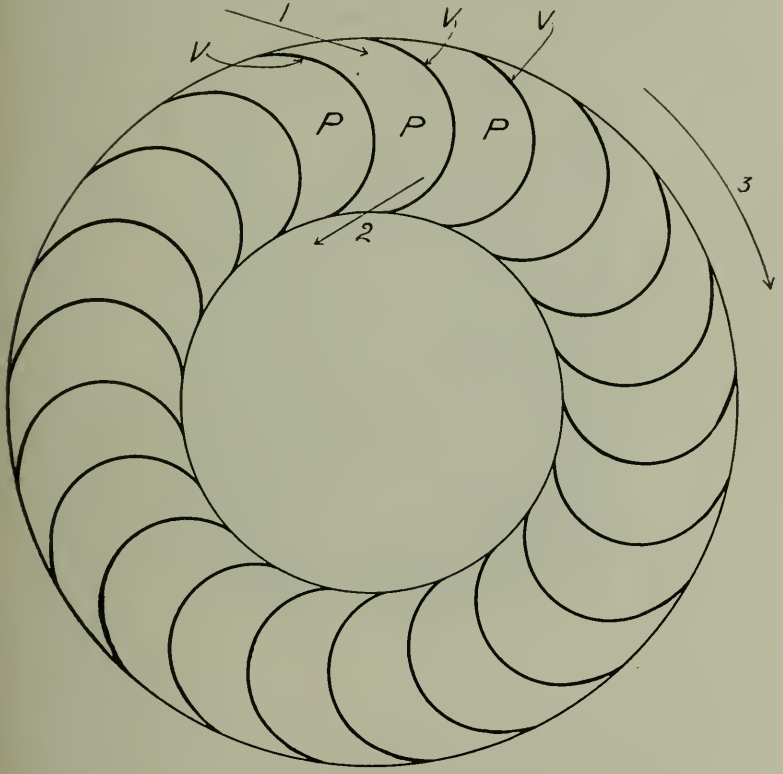


PLATE I.

motor. In a water turbine the fluid is at constant volume and at constant temperature, and its kinetic energy is gained at the expense of potential energy due to pressure or position."

In the DeLaval Steam Turbine, the wheel and nozzles of which are shown in Plate II, the steam is first allowed to expand in one or more divergent nozzles of special construction. This expansion imparts enormous velocity to the steam, its

heat energy being thus transformed into kinetic energy. As the steam issues from the nozzles, it impinges upon the vanes of the wheel, and in its passage through the vanes the direction of its flow is changed and its velocity greatly reduced. The kinetic energy thus absorbed is imparted to the wheel, causing the latter to rotate at high speed.

In the Westinghouse-Parsons Turbine, the steam, after passing through a ring of fixed guide blades (Plate III), impinges on a ring of moving vanes; then passes through another ring of fixed guide blades on to a second ring of moving

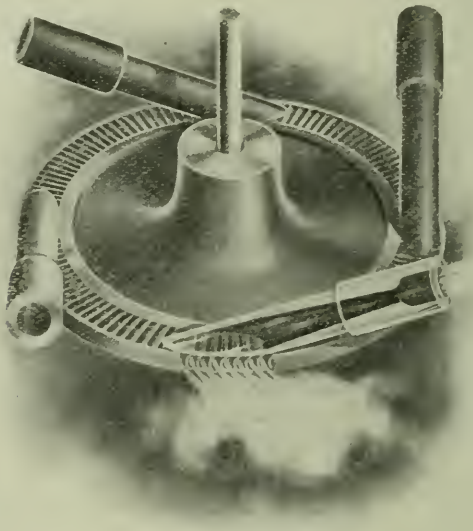


PLATE II.

vanes, and continues through alternate rings of fixed blades and moving vanes until it reaches the exhaust.

The annular space in which the vanes and blades are set increases gradually in size, and the vanes and blades increase correspondingly in length, from admission to exhaust, thus providing the expansion necessary for the conversion of the heat energy into kinetic energy; while at the same time very high rotative speeds are avoided by the gradual absorption of the velocity of the steam by the successive rings of moving vanes.

The Curtis Turbine (Plate IV) is to some extent a combination of the two foregoing types. Steam is admitted through a number of nozzles to a set of alternate rings of moving vanes and fixed blades.

Passing out of the last ring of moving vanes in the first set, the steam, with its expansion only partly completed, passes into a second ring of divergent nozzles from which it is discharged into a second set of alternate rings of moving vanes

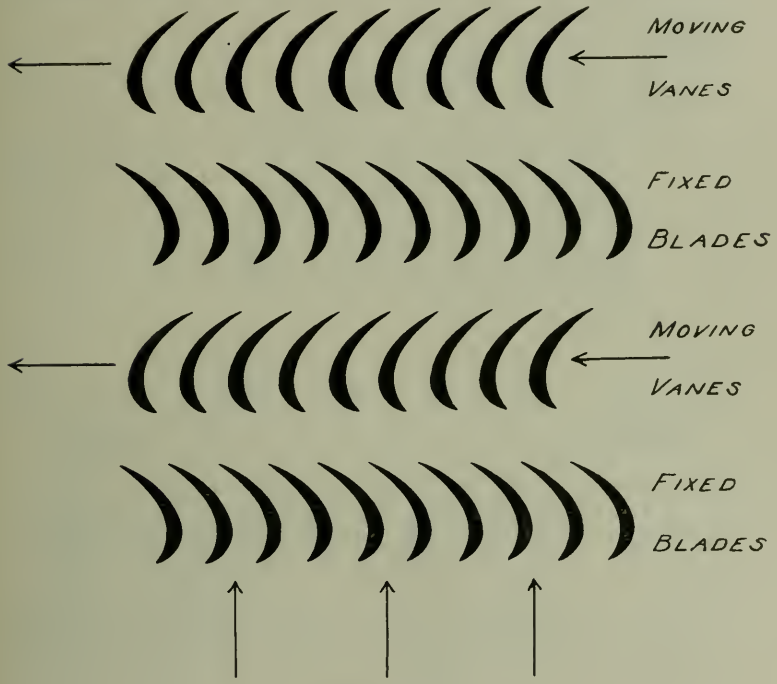


PLATE III.

and fixed guide blades. Each set of rings of vanes and blades, with its nozzles, is called a "stage," and the complete Curtis turbine contains from two to four such stages.

Plate V shows some details of a DeLaval Turbine Wheel and vanes. As will be seen, the vanes, which are drop-forged, are accurately fitted into recesses in the rim of the wheel.

In Plate VI the working parts of a DeLaval Turbine are shown. As the speed of the shaft on which the wheel is mounted is 9,000 revolutions per minute for the largest size

made, and is several times greater for the smallest sizes, a second shaft is added, the speed of which is reduced, by means of double helical gears, to one-tenth of that of the first shaft.

To prevent the hammering that would occur at what is known as the critical speed as a result of the failure to perfectly balance parts rotating at velocities so high, the shaft is

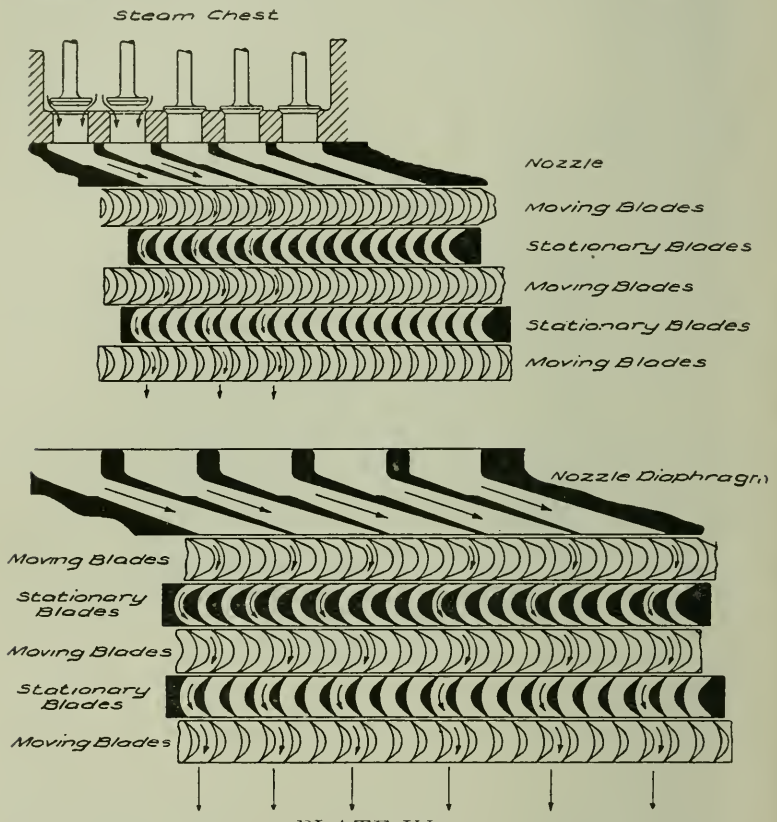


PLATE IV.

made so small as to be flexible, and turns in bearings whose spherical exterior surface is fitted into cups, so that the wheel may be free to rotate about its center of mass instead of about its center of figure.

The DeLaval Company, in addition to its Steam Turbines directly connected to electric generators, manufactures a regular line of centrifugal pumps, to be driven either by electric

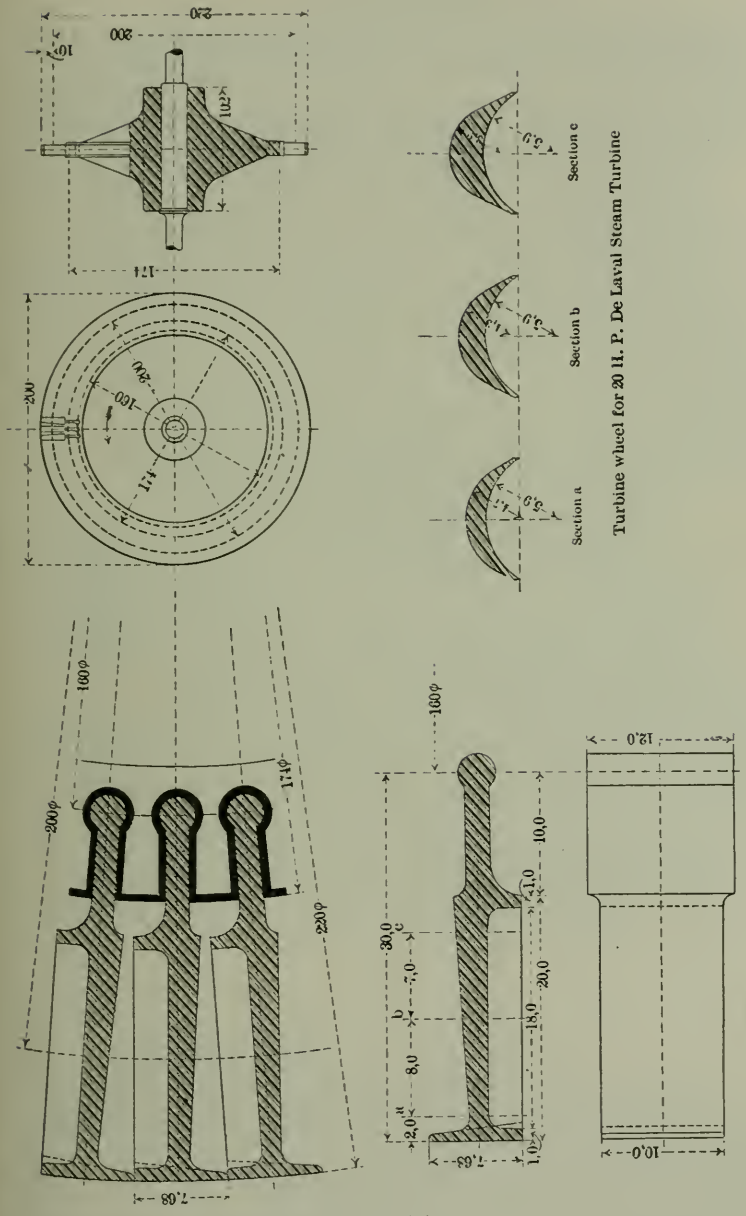


Figure 6.

PLATE V.

motor or by DeLaval Turbines. One of these pumps is shown in Plate VII.

In Turbine pumps of 55 horse-power and under there is usually only one Centrifugal Pump, which is carried by the second or power shaft. (See Plate VIII).

For larger sizes there are two second shafts each geared to the first shaft and each carrying a Centrifugal Pump, as shown in Plate IX.

These Centrifugal Pumps may be either connected in series or in parallel. Plate X shows the pumps connected in series. For lifts of 500 feet or over, two pumps are connected in

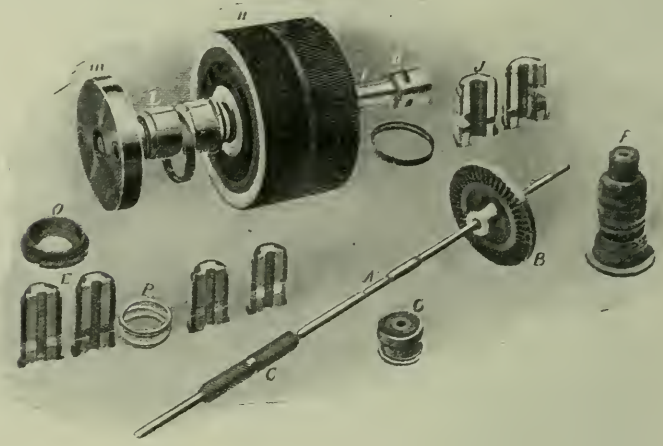


PLATE VI.

series, one of them being driven directly by the first, or more swiftly moving, shaft and the other carried by the second shaft.

Plate XI is a sectional elevation of a typical Westinghouse-Parsons Steam Turbine, the principal structural features are clearly shown. From inlet A to exhaust B the steam passes, expanding as it goes, through alternate rings of fixed and moving blades. End thrust is balanced by the pistons P, which are of the same respective diameters as the drums carrying the moving vanes, the pressure on each balancing piston being kept equal to that on the corresponding drum by means of the connections E. The balancing pistons revolve within their

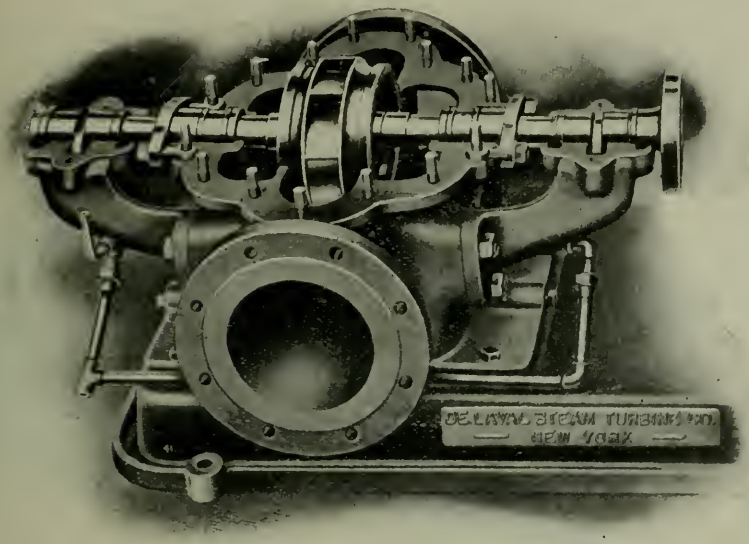


PLATE VII.

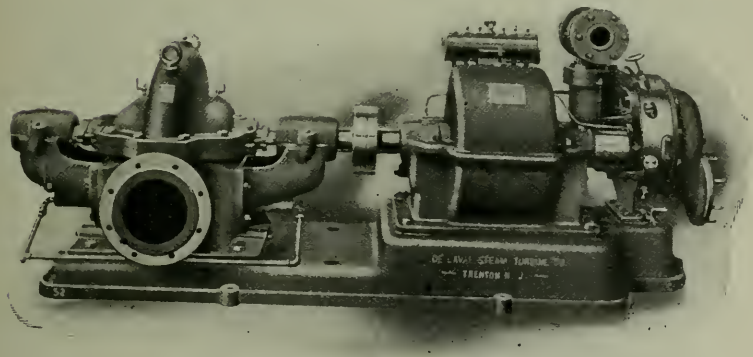


PLATE VIII.

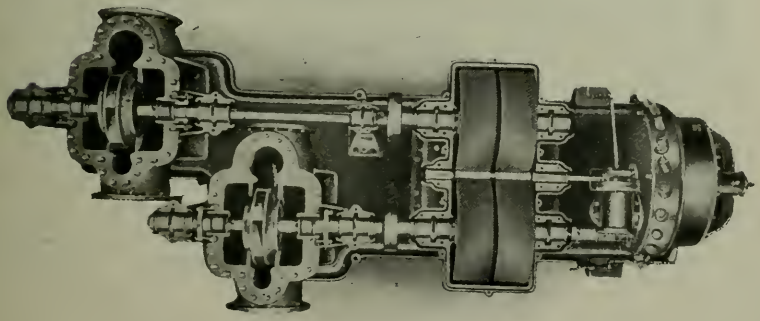


PLATE IX.

respective cylinders with a close fit, but are not in mechanical contact.

There is a small thrust bearing T, for end-adjustment of

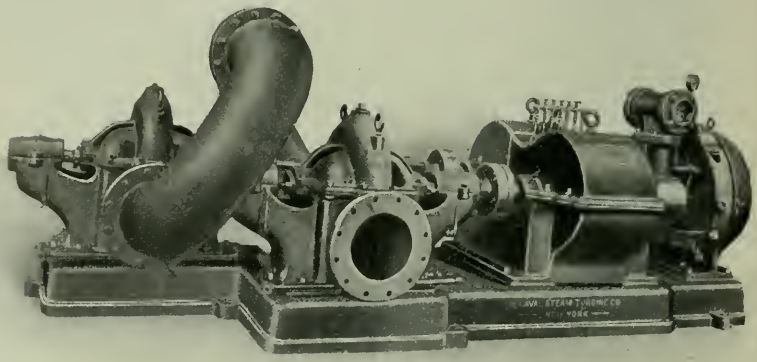


PLATE X.

the rotating parts, so that normal clearances may be maintained between fixed blades and moving vanes. In actual practice these clearances are never less than one-eighth inch,

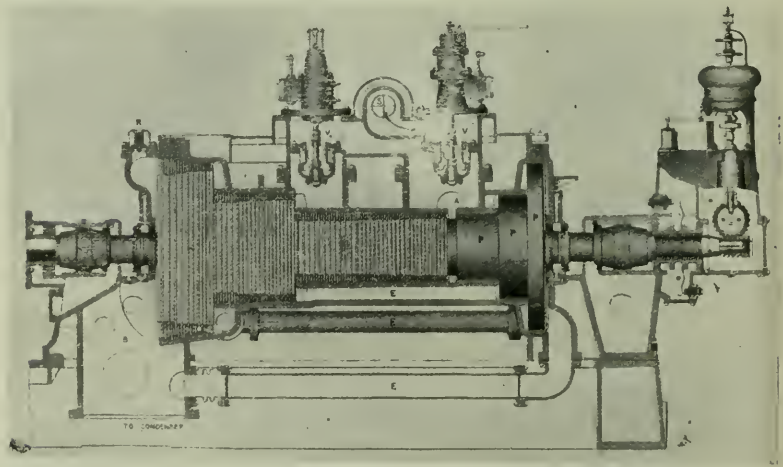


PLATE XI.

and in large blades may be as great as one inch.

To prevent air being drawn into the condenser, the Annular

Spaces around the shaft near its ends are supplied with live steam. Steam enters the Turbine in puffs, not in a continuous blast, and the governing is effected by increasing or diminishing the duration of the puffs. The governor is driven by a worm on the end of the turbine shaft, and its up-and-down motion is communicated by rods and levers to the pilot valves which in turn operate the main poppet valve, V. There is also a second poppet valve, Vs., by means of which steam at full pressure may be admitted directly to the second drum, thus giving the turbine a large overload capacity.

To absorb the vibrations caused by any possible lack of balance at critical speed, a special type of shaft bearing is provided

PLATE XII.

for turbines of small or medium size. See Plate XII. This consists of a case containing a nest of loosely fitting concentric bronze sleeves, with sufficient clearance between them to insure the formation of oil films. These form cushions, permitting a certain amount of vibration of the shaft, but at the same time absorbing and restraining it within narrow limits. For speeds of less than 1,200 revolutions per minute, this bearing is considered unnecessary.

Plate XIII shows a 600 H. P. Westinghouse-Parsons Turbine, opened for inspection.

Plate XIV shows two 5,000 K. W. generating units, one being a Modern Vertical Engine Unit and the other a Westinghouse-Parsons Unit, and illustrates the difference in space

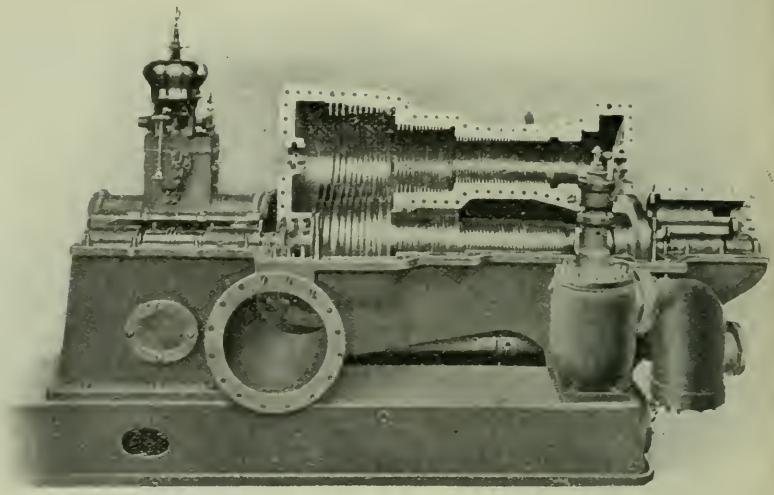


PLATE XIII.

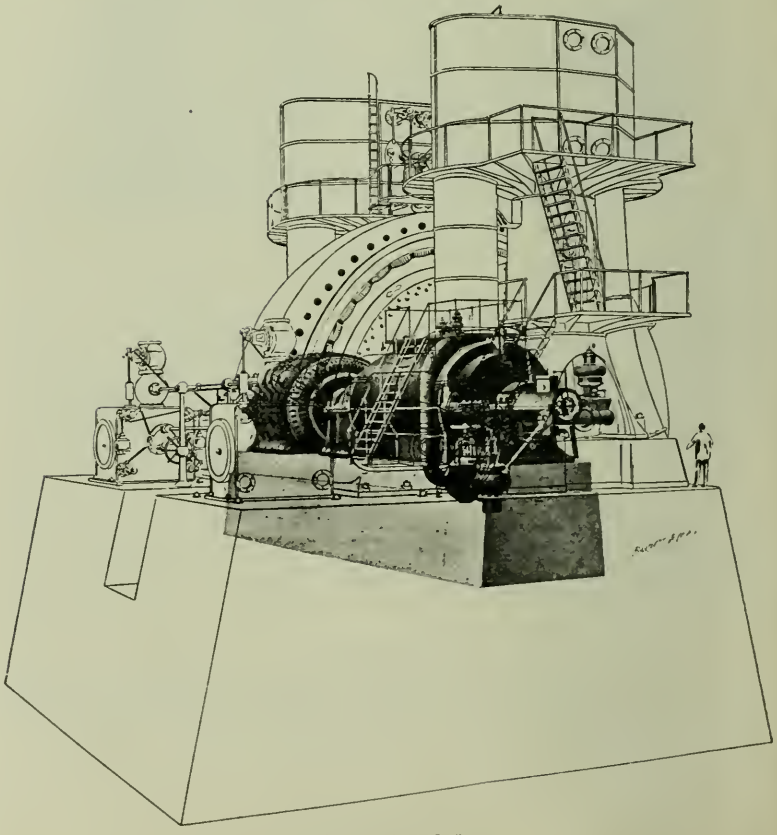


PLATE XIV.

and foundations required for the two types.

Plate XV shows the comparative sizes of a vertical reciprocating engine with generator and of a Curtis Steam Turbine Generator of same capacity.

Plate XVI shows the nozzle, a segment of revolving vanes, a segment of fixed vanes, and a view of a Curtis Turbine under construction.

All Curtis Turbines of 500 K. W. and over are now made vertical, and the weight of the moving parts is "floated" by pumping oil or water under a step bearing at the bottom of the shaft, shown in Plates XVII and XVIII. Oil was formerly used, but water is now preferred.

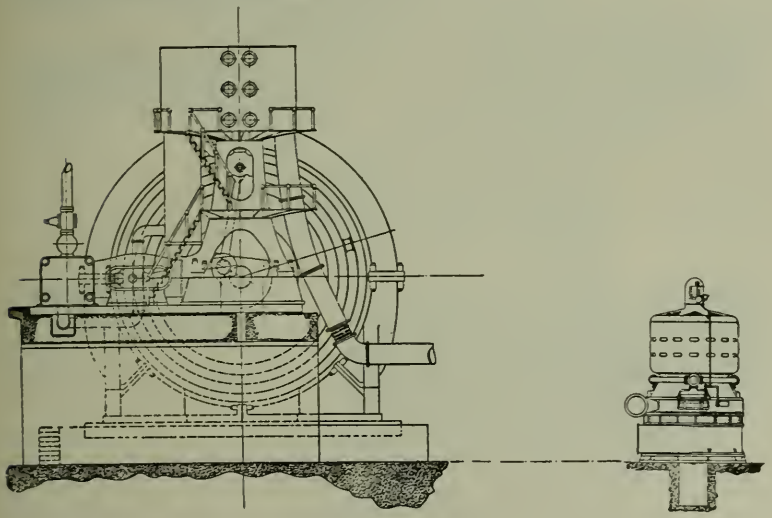


PLATE XV.

The General Electric Co. has of late been manufacturing smaller sizes of Steam Turbines, like the one shown in Plate XIX.

The foregoing illustrations, while they clearly show some of the principal structural details of the three types of turbine under discussion, give no adequate idea of the excellence of the material and workmanship embodied in the manufacture of all these machines.

The modern steam turbine may be regarded as an accomplished fact. Each type, as at present developed and manu-

factured for sale, is the product of the best work of some of the very best designing engineers in this country or abroad. Neither of the three types was put on the market in this country until it had been carefully tested for years under all sorts of conditions, by a Company so strong financially that it could afford to spend all the money necessary to make its product a success, and of standing so important that it could not afford to do anything else.

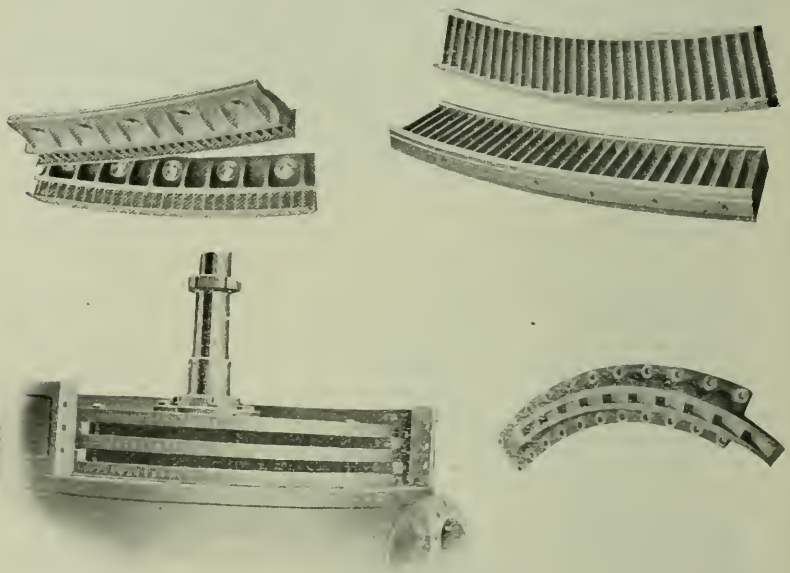


PLATE XVI.

The attitude of aloof expectancy with which the general public has watched for failures in certain structural details of each of these types may now well give place to a confidence that, in so far as the steam ends of these three turbines are concerned, their design and construction are admirable for the purposes, and within the limitations, for which they are built and sold.

The De Laval Turbine has been manufactured abroad for 10 years, where between 3,000 and 4,000 machines have been sold, aggregating about 300,000 horse power.

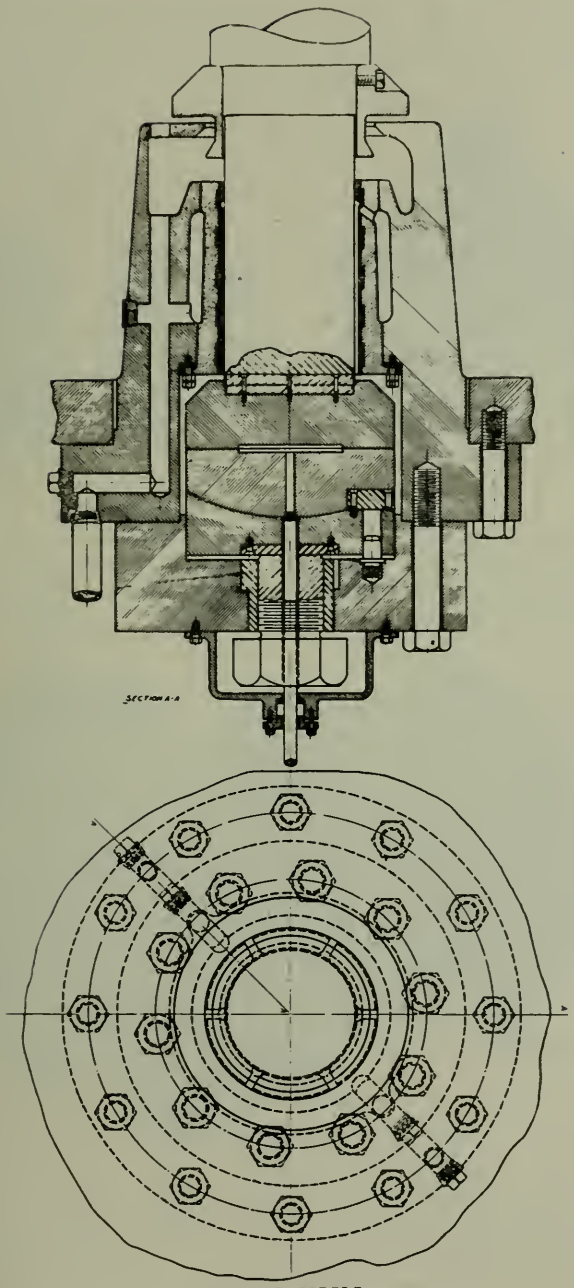


PLATE XVII.

De Laval Turbines have been made in the United States for the past three years, about 25,000 horse power having been sold.

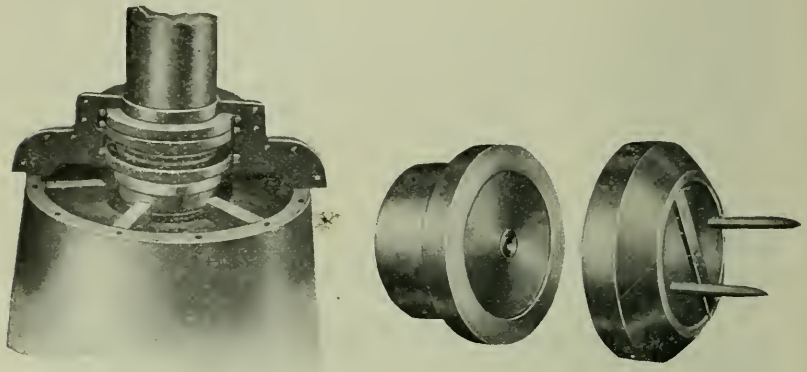


PLATE XVIII.

The Westinghouse Company has sold in the United States upwards of 200,000 horse power of turbines built under the Parsons patents.

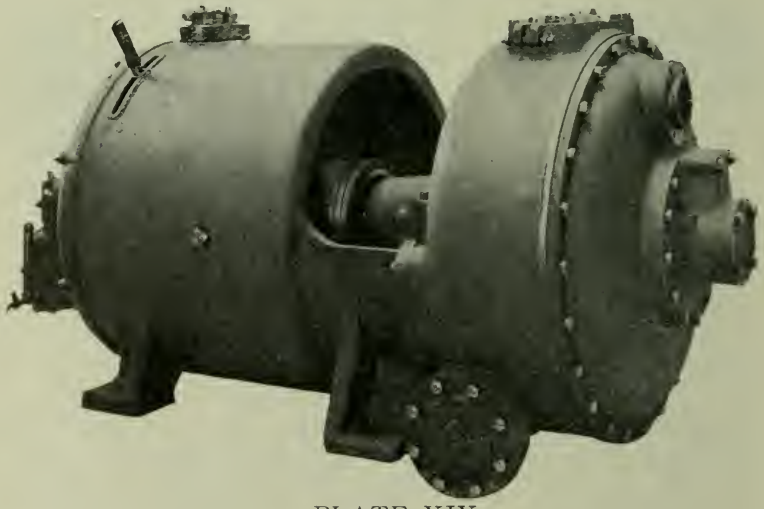


PLATE XIX.

The sales of Parsons Turbines abroad have been, of course, very much larger, and include turbine engines installed in a

HORSE POWER, SPEEDS, CAPACITIES, HEADS AND APPROXIMATE COSTS OF DE LAVAL STEAM TURBINE PUMPS.

BRAKE HORSE POWER.	REV. PER MIN.		CAPACITY	HEAD IN FEET.	COST OF TURBINE PUMP WITHOUT CONDENSING SET.	COST OF COMPLETE CONDENSING SET FOR 26" VACUUM.	COST TURBINE PUMP WITH CONDENSING SET FOR 26" VACUUM.	COST OF COMPLETE CONDENSING SET FOR 28" VACUUM.	COST TURBINE PUMP WITH CONDENSING SET FOR 28" VACUUM.
	1ST. SHAFT.	2ND. SHAFT.	GALS. PER MIN.						
7	30,000	3,000	170	90	508.00				
10	24,000	2,400	180	120	590.00				
15	24,000	2,400	290	120	675.00				
20	20,000	2,000	400	120	900.00				
30	20,000	2,000	360	180	1,090.00				
55	15,000	1,500	700	180	1,605.00				
75	15,000	1,500	775	250	2,200.00	350.00	2,550.00	550.00	2,750.00
110	12,000	1,200	1,250	250	3,212.00	450.00	3,662.00	750.00	3,962.00
150	12,000	1,200	1,700	250	4,280.00	600.00	4,880.00	1,000.00	5,280.00
225	9,000	900	2,500	250	6,205.00	900.00	7,105.00	1,450.00	7,655.00
300	9,000	900	3,300	250	6,602.00	1,100.00	7,702.00	1,800.00	8,402.00

PUMPS OF 75 TO 300 H.P. ABOVE LISTED CAN BE MADE TO PUMP AGAINST 350 FEET HEAD WITH APPROXIMATELY CORRESPONDING DECREASE IN CAPACITIES. PRICES TURBINE PUMPS ARE F.O.B. TRENTON, N.J. PRICES CONDENSING SETS INCLUDE SURFACE CONDENSERS, AIR PUMP, CIRCULATING PUMP, AND CONNECTIONS, F.O.B. FACTORIES. PUMPS FOR 500 FEET HEAD ARE ALSO MANUFACTURED, CONNECTED TO TURBINES OF FROM 15 TO 300 H.P.

PLATE XX.

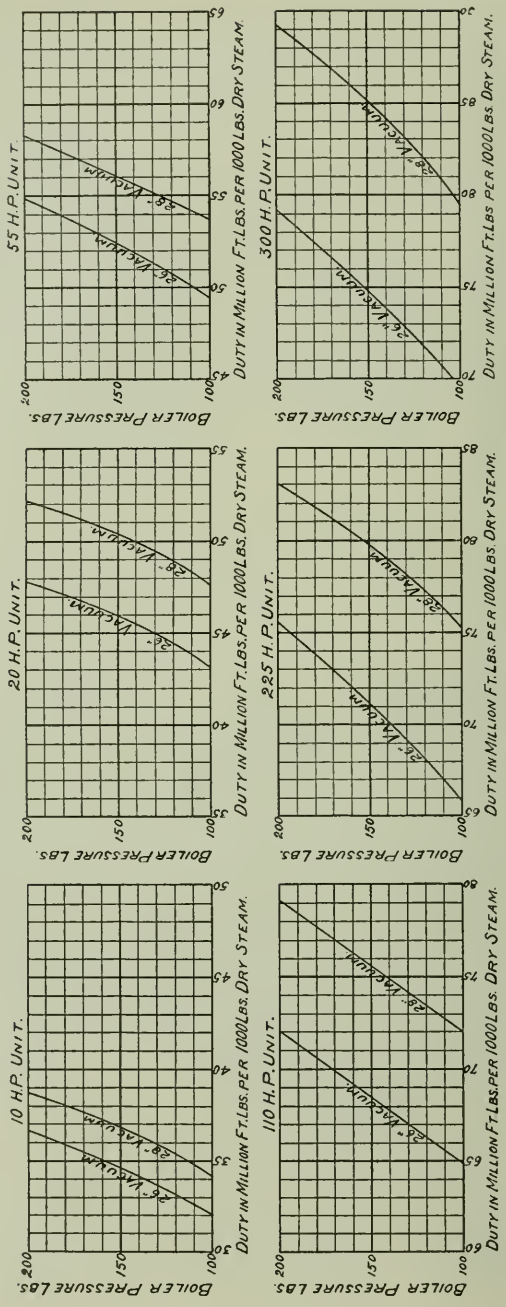

DUTY OF DE LAVAL STEAM TURBINE PUMPS, IN WATER LIFTED. NO SUPERHEAT.
10 H.P. UNIT.
DUTY IN MILLION FT. LBS. PER 1000 LBS. DRY STEAM.
BOILER PRESSURE LBS.
110 H.P. UNIT.
DUTY IN MILLION FT. LBS. PER 1000 LBS. DRY STEAM.
BOILER PRESSURE LBS.
20 H.P. UNIT.
DUTY IN MILLION FT. LBS. PER 1000 LBS. DRY STEAM.
BOILER PRESSURE LBS.
225 H.P. UNIT.
DUTY IN MILLION FT. LBS. PER 1000 LBS. DRY STEAM.
BOILER PRESSURE LBS.
55 H.P. UNIT.
DUTY IN MILLION FT. LBS. PER 1000 LBS. DRY STEAM.
BOILER PRESSURE LBS.
300 H.P. UNIT.
DUTY IN MILLION FT. LBS. PER 1000 LBS. DRY STEAM.
BOILER PRESSURE LBS.

PLATE XXI.

HORSE POWER, SPEEDS, CAPACITIES, HEADS, AND APPROXIMATE COSTS OF WESTINGHOUSE PARSONS STEAM TURBINE CONNECTED TO CENTRIFUGAL PUMPS.

Brake Horse Power	Rev. per Min.	Capacity Gallons per Min.	Head in Feet.	Cost of Turbine Alone.	Cost of Turbine and Pump.	Cost of Condensing Set for 26" Vacuum.	Cost of Turbine, Pump and Condensing Set for 26" Vacuum.	Cost of Condensing Set for 28" Vacuum.	Cost of Turbine, Pump and Condensing Set for 28" Vacuum.
425	1,500	4,700	250	10,800	13,000	1,600	14,600	2,700	15,700
565	1,500	6,300	250	13,200	15,600	2,000	17,600	3,500	19,100
705	1,500	7,800	250	15,000	17,600	2,400	20,000	4,200	21,800
1,060	1,500	11,800	250	20,250	23,050	3,300	26,350	6,000	29,050
1,410	1,500	15,700	250	24,000	27,000	4,200	31,200	8,000	35,000

PRICES OF STEAM TURBINES ARE F.O.B EAST PITTSBURG, PA. PRICES OF CENTRIFUGAL PUMPS ARE ESTIMATED. NO PUMPS AS YET MADE BY WESTINGHOUSE COMPANY FOR DIRECT CONNECTION TO ITS STEAM TURBINES. PRICES OF CONDENSING SETS INCLUDE SURFACE CONDENSER, AIR PUMP, CIRCULATING PUMP AND CONNECTIONS, F.O.B. FACTORIES.

PLATE XXII.

ESTIMATED DUTIES OF WESTINGHOUSE PARSONS STEAM TURBINES DIRECT CONNECTED TO CENTRIFUGAL PUMPS.

CURVES SHOW DUTIES IN WATER LIFTED IN MILLION FOOT LBS. PER 1000 LBS. DRY STEAM. THESE DUTIES ARE REDUCED FROM A LARGE NUMBER OF PUBLISHED TESTS SHOWING WATER RATES PER E.H.P. AND PER B.H.P., BY ASSUMING 95% EFFICIENCY FOR GENERATOR AND 70% EFFICIENCY FOR CENTRIFUGAL PUMP. TESTS MADE AT ABOUT FULL LOAD AND WITH AVERAGE BOILER PRESSURE OF 150 LBS.

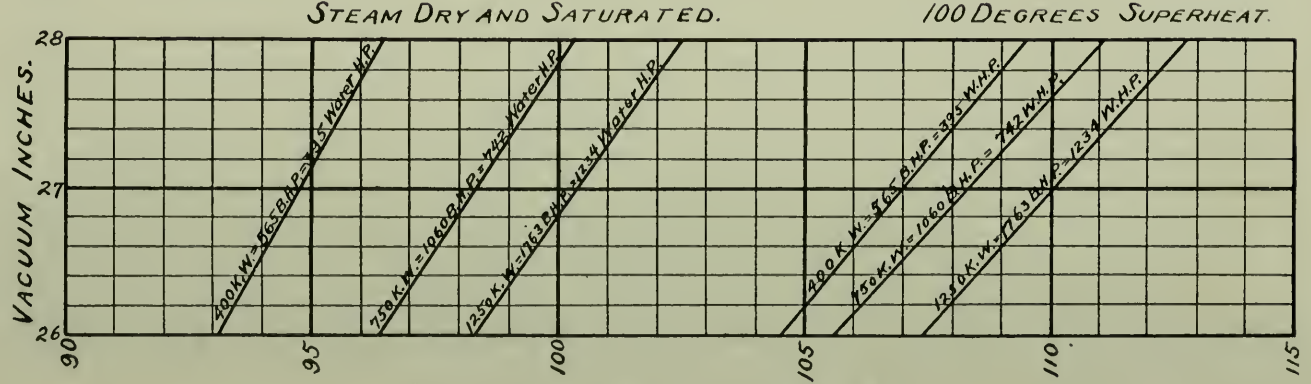


PLATE XXIII.

number of vessels, from small torpedo craft up to large merchant ships.

The sales of Curtis Steam Turbines up to date have been 330 units, aggregating 354,900 K. W., or about 500,000 brake horse power.

Among the advantages of the steam turbine as a motor may be cited the following:—

High efficiency.

Low first cost.

Small floor space and head room.

Small expense for building and foundations.

Small expense for care and attendance.

Low depreciation and maintenance.

Freedom from vibration.

Simplicity of packing.

Small number of bearings, and of moving parts.

Readiness with which repairs can be made and parts renewed.

Comparatively small size of all parts, insuring more perfect material.

No oil in condensed steam, thus practically solving the serious problem of feed water.

Coming next to the water ends of Steam Turbine Pumps, the present commercial conditions are not quite so good, though there is promise of some improvement.

The Turbine Engineering Company, which builds the De Laval turbines in the United States, is the only company that has so far turned its attention to supplying waterworks needs.

Plate XX is a table giving commercial data in regard to De Laval steam turbine pumps.

While the De Laval Company does not appear to have yet taken up the manufacture of pumps having guide blades for absorbing the whirling motion of the water leaving the impeller, or "turbine pumps," as they are called, it has worked out carefully the design of its high speed centrifugal pumps, and is prepared to furnish them in many sizes up to 300 horse power. These pumps are adapted to greatly varying services, and published tests show that the pump efficiency can be maintained close to its maximum over a very wide range of horse powers.

Plate XXI shows duty curves of various sizes of De Laval steam turbine pumps under various conditions. These curves were platted by the writer from data supplied by the Turbine Engineering Co. For 200° superheat, the duties shown should be increased by about 10 per cent.

Plate XXII gives commercial data with regard to Westinghouse-Parsons steam turbines.

The duty curves of Westinghouse steam turbines, shown in Plate XXIII, have been platted from the averages of a large number of published tests. The duties in water pumped have been figured from the steam consumption per brake horse power per hour, an efficiency of only 70 per cent. being assumed for the centrifugal pump which it is supposed would be used in connection with the turbine. The curves were platted from tests made at or near full load. Considerably higher duties were shown by tests at moderate overloads.

Sizes and Speeds of Curtis Turbines Manufactured.

Turbine Units	Brake Horse Power	Rev. per Min.
5000 A.C.	7000	500
3000 A.C.	4250	600
2000 A.C.	2800	750
1500 A.C.	2150	900
1000 A.C.	1450	1200
800 A.C.	1150	1500
500 A.C.	700	1800
100 A.C.	145	3600
500 D.C.	700	1800
300 D.C.	425	2000
150 D.C.	215	2000
75 D.C.	110	2400
25 D.C.	35	3600
15 D.C.	21	4000
All Curtis Turbines of 500 K.W. and above are Vertical.		

PLATE XXIV.

Plate XXIV shows sizes and speeds of Curtis steam turbines.

No prices can be quoted on Curtis steam turbines separate from the generator, as, so far, these turbines have been made solely for use with General Electric generators.

Tests of a 500 K. W. turbine, one of the first commercial Curtis turbines built, conducted by Mr. Geo. H. Barrus for the

owners, and Messrs. Richard H. Rice and A. R. Dodge for the General Electric Co., showed, for loads varying from 375 to 750 K. W., with steam at about 145 lbs., with a vacuum of 95 per cent., and with superheat of from 125° F. to 151° F., a water rate that ranged from 17.8 to 18.4 lbs. per kilowatt-hour, and average 18.1 lbs.

Assuming a generator efficiency of 95 per cent., the average water rate per brake horse power per hour would be 12.84 lbs.; and assuming that this steam turbine could be connected to a centrifugal pump having an efficiency of 70 per cent., the resulting duty in water lifted per 1,000 lbs. steam would be about 108,000,000 ft. lbs.

The efficiency of the pump has been assumed by the writer in all of the foregoing calculations of duties at 70 per cent., for the reason that that figure may be safely expected from modern centrifugal pumps of the sizes considered. As the duties of the De Laval pumping units were based upon tests made of steam turbines connected to centrifugal pumps, it was only fair that the use of the same style of pump should be assumed in connection with the other two types of steam turbines.

It may reasonably be expected, however, that the efficiency of the modern "turbine pump," of large capacity and high lift, will ultimately approximate the efficiency of its prototype, the hydraulic turbine, and reach 80 or 85 per cent. instead of 70 per cent. In this event, the duties given in this paper would have to be increased by from 15 to 20 per cent.

While even these duties would be somewhat lower than might be obtained with the very best types of reciprocating pumping engines, the numerous other advantages of the steam turbine pumping unit will doubtless in a great many cases give it the preference over the reciprocating pump.

In the present state of the art, the time has come for the development, either by the manufacturers of the steam turbines, or by pump builders already in the field, of a class of modern high speed turbine pumps, of high efficiency, and suitable for direct connection to the shafts of steam turbines.

DISCUSSION.

Mr. Boardman: Mr. Maury handed me a draft of his paper to-night requesting me to criticise in any way I saw fit, and to open the discussion.

Mr. Maury has stated the case so minutely, has covered the ground so thoroughly, and has been evidently so fair in comparison of the various types, that I hardly think a criticism can be made of the paper, and it only remains now for experience to prove whether his figures are altogether correct when these engines are subjected to practical every day work under water works conditions, as compared with reciprocating engines.

I must say that I have very great hopes myself that Mr. Maury's prognostications will prove true in regard to the value and the efficiency of turbine machines. I have no further criticism to make.

Mr. Meyers: I had occasion a year ago to look into the De Laval pump in a small way for low service pumping. I was given to understand that there was only ten per cent. variation from the normal rate of speed of the motor allowable.

I would like to ask Mr. Maury if his investigations show the same thing, and if so, whether this would not be objectionable in a great many ways.

Mr. Maury: I should have made it more clear that the variations in efficiency was not due entirely to the variation in speed of the motor. You may pump a relatively large quantity of water against a low head, or a relatively small amount of water against a higher head without any very great variation in speed, and the resulting variation of efficiency is comparatively slight for a wide range of total load.

Mr. Meyers: What I meant was this, in operating a filter plant at low rate, for instance, on direct service at night, if a turbine pump were used for pumping water to the filters it would be advisable to run the pump at a low rate of speed, but as the turbine people only allow a ten per cent. variation from the normal speed of the pump, owing to the necessity of maintaining the harmonic centre of the motor

shaft, it seems to me that it would make it inadvisable to use a turbine pump for this purpose.

Mr. Maury: It may be true that the steam turbiine is not so elastic a unit in that respect as a reciprocating engine. I did not take up the question as to just how much total variation in speed could be allowed in the steam turbine and so I cannot answer the question as well as I should like to; but the tests to which I referred as showing only slight variation in efficiency for wide variations in load were more particularly tests of the pump alone when driven by a motor for the purpose of testing.

Mr. Boardman: I would suggest that the point raised might be overcome in this way; the speed of the motor might be kept constant, thus maintaining the particular speed necessary for the pump, the amount of water required being controlled by a valve on the outlet of the pump; understanding, of course, that as the valve is closed off the centrifugal pump the load is decreased; and as the load is decreased, the amount of steam entering the steam turbine will be decreased. But the velocity of the turbine and the velocity of the pump remain the same. The objection raised by the turbine company was, that they will not allow you variation in the speed of the machine—not in the load. You must maintain the speed but can still change the load, and so economize in steam consumption.

Mr. Maury: In that case, the turbine pump will simply churn some of the water.

Mr. Hague: I have listened with a great deal of interest to Mr. Maury's description of this scientific toy.

I compliment him on the clear and rational manner in which he has presented this before the association. It is perfectly evident that he has put his best foot forward to show the steam turbine, especially with reference to the pumpage of water, to which field I purpose to confine my part of the discussion; but, nevertheless, when compared with the same quality and standard of reciprocating engine, the steam turbine as here described is still a very long ways in the rear; and probably to bring this matter to a direct point, a good comparison would be to show the cost of

pumping in money, which is probably the point of view from which practical water works people would consider this matter.

Taking 10,000,000 gallons, for example, against 100 pounds pressure, the net pump horsepower would be 400 horsepower. Now the mechanical efficiency of a reciprocating pump, that is the pump proper, is about 98½ per cent.; and the amount of power necessary to add to cover the loss of water so as to bring the delivery up to 100 per cent. would be slight—about 1½ per cent. As far as we have been able to ascertain, the hydraulic efficiency of the turbine pump is in the neighborhood of 70 per cent. A great many are only guaranteeing 65 per cent.

It is perfectly evident that the amount of power to be added to overcome this deficiency of flow is very much greater in the turbine pump.

I have gone over this matter, while listening to the paper as nearly as I could without pencil and paper, and I have arrived at the conclusion that a reciprocating pump of a type equivalent in quality to the turbine type exhibited here would show 96 per cent. efficiency, whereas the mechanical efficiency of a turbine is about 70 per cent. I have had a little experience in those lines, and that is about where the figures land.

Now a pumpage of 10,000,000 gallons against 100 pounds pressure will require a little over six tons of coal a day with a reciprocating engine on a steam consumption of 10½ pounds of steam per indicated horsepower per hour, which is a little above the best exhibit so far. The steam consumption of a turbine steam engine so far with superheated steam, is about 12½ pounds of steam per indicated horsepower per hour, and upon this basis applied to the gross horsepower required to pump 10,000,000 gallons in both cases, we find 6 1-5 tons of coal used by the reciprocating engine, and a little over 10 tons for the turbine engine. With coal at $3.00 per ton the difference would pay five per cent. on $80,000. Taking a reciprocating engine of say 10,000,000 gallons capacity, with foundations ready for service, at about $60,000, and with a 10,000,000 gallon turbine

pumping engine with steam turbine driver, which would certainly come to $35,000, the difference in the steam consumption alone, with reasonable amount of wear and tear allowed of say three per cent. in both cases—and there is absolutely no evidence to show that the turbine will keep down to three per cent.—and there are contracts made on large high type reciprocating engines under the terms of which contractors guarantee two per cent. per annum as the amount necessary for repairs, but with all charges made and the account balanced, the best type of reciprocating engine, with dry saturated steam, will earn five per cent. return upon $60,000 over the best type of turbine engine driving a turbine pump.

When stating that conclusion, I am allowing everything that has been so far said in favor of the turbine machine, and some of it will hardly stand for the test of actual practice. In making this statement, gentlemen, of course you will understand that I am trying to stand on hard facts. I haven't any interest in any particular engine. I simply want to be in the front rank; wherever the best engine is, that is where I want to be found. But I can not shut my eyes to facts, nevertheless, and these figures I have given you, although rough and ready, are practically accurate, derived from actual water works experience. In actual service, I believe the difference will be even greater.

Mr. Maury: Like Mr. Hague, I am not in any way interested in the manufacture or sale of any type of engine or pump. I do not claim universal superiority for turbine pumps over reciprocating pumps. But I do claim that there is already a field in which the steam turbine pump can successfully compete with the reciprocating pumping engine, and that that field is increasing.

As stated in my paper, makers of turbine pumps are guaranteeing at present only 70 per cent. mechanical efficiency; but they expect to realize considerably more, and claims of over 80 per cent. pump efficiency have already been made.

It is admitted that the mechanical efficiency of the very highest type of large size reciprocating pumping engine has reached, under test conditions, and in exceptional cases, the

figures quoted by Mr. Hague; but Mr. Hague has chosen for comparison the very best type of reciprocating engine and is pitting its test performance against what might be termed the average performance of a turbine pump. He has also chosen conditions which are far from the average ones, and these conditions are exactly those most favorable to the reciprocating engine.

Furthermore, Mr. Hague's statement that the difference in cost of coal alone in favor of the reciprocating engine would pay five per cent. on $80,000, might possibly lead the unthinking to suppose that the reciprocating engine had some other advantages besides low fuel cost, and that it was customary to capitalize investments in pumping machinery at only five per cent.—both of which suppositions would be erroneous.

While it is unfair to the turbine unit to pick out as a basis of general comparison of the whole range of pumping station practice, units of 10,000,000 gallons capacity, when hardly one pump in a thousand is so large, let us see how the two units of this size would actually compare under fair average working conditions.

Let us grant that the actual continuous working duty of the reciprocating engine would be 170,000,000 foot pounds per 1,000 pounds dry steam—which is within five per cent. of what is, according to Mr. Hague, the very best test performance ever recorded. Then let us assume 80 per cent. efficiency for the turbine pump—which has been exceeded already—and apply this efficiency to the diagrams of duties of Westinghouse turbine pumps given in my paper, instead of the 70 per cent. efficiency which formed the basis of those charts. The result would be a duty—averaged from a large number of published tests of the steam turbine, not based on the very best performance ever obtained, of 125,000,000 foot pounds per 1,000 pounds dry steam.

If the two pumping units are supposed to work side by side, pumping 10,000,000 gallons against 100 pounds pressure in every 24 hours, the daily work done by each unit would be 19,250,000,000 foot pounds. Assuming an evaporation of eight pounds of steam per pound of coal, the coal

required per day for the reciprocating pump would be 14,154 pounds and for the steam turbine pump, 19,250 pounds.

Making next the further assumption that each unit works at exactly full load for 24 hours 365 days in the year, with coal at $3.00 per ton, the annual fuel cost would be $7,749 for the reciprocating engine, and $10,539 for the steam turbine pump. This shows, with $3.00 coal, an annual saving of $2,790 for fuel in favor of the reciprocating engine.

Such an engine would cost, according to Mr. Hague, $60,000. The turbine engine of like horse power would not cost anywhere near $35,000, the figure quoted by Mr. Hague, but, according to the prices given in the charts accompanying my paper, would cost, complete with condensing set for 28-inch vacuum, and with foundations, not over $20,000.

Two thousand seven hundred and ninety dollars at five per cent. would capitalize $55,980 (not $80,000). But it is not customary to neglect depreciation in comparing costs of pumping plants. While it is true that three per cent. per annum might take care of the actual repairs to a complicated reciprocating engine and certainly ought to be ample for repairs to a steam turbine unit having practically only one moving part and that part in rotary motion, it is also true that a great deal of machinery has to be abandoned because it is obsolete or because of change in working conditions, long before it is worn out. Something new and better is always being developed. Just as steam turbine generating units will undoubtedly, in some cases, crowd out reciprocating generating units long before the latter are worn out, so also gas producer plants, or some other new development, may take the place of steam plants for pumping.

Depreciation at four per cent. would, therefore, be none too high; and with interest at five per cent., the annual saving in coal by the reciprocating steam plant would capitalize only $31,000.

To compare the two units we should then have to charge the steam turbine unit with $20,000 plus $31,000 equals $51,000, against $60,000 for the first cost of the reciprocating steam pumping engine, showing a difference of $9,000 in

favor of the steam turbine unit.

But Mr. Hague must admit that no pumping engine of any type can be expected to run at full load 24 hours per day, 365 days per year, for twenty-five years. A pumping capacity of at least double the average load is required in almost every station, and often the reserve capacity is much greater. It would certainly not be unfair to the reciprocating engine to compare it with the turbine unit on the assumption that both units will average one-half time for the twenty-five-year period.

Under these conditions, the annual saving in fuel by the reciprocating unit would be only $1,395; which at nine per cent. would capitalize only $15,500. The turbine unit could thus be charged with only $20,000 plus $15,500 equals $35,500, as against $60,000 for the reciprocating unit, making a difference in favor of the steam turbine pumping unit of $24,500.

These comparisons have been made on the basis of $3.00 per ton for coal. With cheaper coal, the advantage of the turbine unit over the reciprocating unit would be still greater, and while coal at some points in the United States costs more than $3.00 per ton, there are large areas over which it can be bought for considerably less than $2.00 per ton.

Low cost for fuel is the one point on which the reciprocating unit has any advantage at all over the turbine unit. and, as has just been proven, the low first cost of the turbiine unit will, under anything like fair average conditions, far more than offset this difference in fuel cost. When it is further remembered that in every other respect—small floor space; small cost for buildings; simplicity; low cost of attendance; and freedom from oil in the feed water—the turbine unit has the advantage, it must, I think, be conceded that so far as successful competition with reciprocating steam pumping engines is concerned, the field for the turbine pump is already a wide one, and, with the improvements naturally to be expected, must soon grow wider.

Mr. Hague: It has often been said that coming events cast their shadows before. I think the shadow of this

event has gone to its utmost limit; and as far as I can see from a thermo-dynamic standpoint and that of mechanical construction, there is very little room for improvement in the present turbine engine, which to get its best results requires superheated steam, which is a condition not very often found in water works.

At the National Engineering Congress last October, the Westinghouse representative acknowledged that they did not know the cost of superheated steam; consequently, what we call the commercial value of this apparatus can not be determined. We must know the cost of superheated steam before we can determine what it is worth. It is also a question of high vacuum. We all know that the slightest resistance to a turbine engine on the condenser end will very rapidly reduce the efficiency; and in the every day water works practice of handling water with machinery in the hands of the men you can afford to employ, these details become of great importance.

Now in the matter of pumping engines of 10,000,000 gallons capacity—and I take that simply as an illustration; as a matter of fact the highest type of engines are built down as small as 5,000,000—as I stated in my paper yesterday, the shop practice to-day has been so perfected that a triple expansion engine of 5,000,000 gallons capacity can be built and sold at a fair price. Further than that, as all of our cities enlarge, which they have for the past ten or fifteen years, the pumping unit is gradually increased. The late Henry R. Worthington some years ago drew the limit of 10,000,000 gallons as the maximum capacity of a pumping engine. Now that limit rises as high as 40,000,000 gallons. In a large city like Chicago, where the entire water supply depends upon machinery, the limit has gone up fourfold. A 15,000,000 gallon engine is quite a toy for a water works engine in Chicago. Of course, the restrictions which handicap the reciprocating engine will also handicap the turbine engine to a certain extent, so that when we sum it all up and place everything on an every day practical basis, the difference in the consideration of the capacities will not change things very much.

Mr. Alvord: I would like to ask Mr. Hague for information: if what he says is so, why is it that we see some of our best engineers designing and installing large turbine units in large central electric stations in preference to reciprocating engines—turbines of the largest type.

Mr. Hague: Well, in the first place, there is no particular evidence that the *best* engineers are doing that; and in the next place I said at the outset that I should confine myself to the water works field; and I will acknowledge that there are very good prospects for the turbine engine in driving electrical machinery. The principal advantages are, however, almost entirely incidental. It prevents the use of the enormous electric machines that the reciprocating engine requires; but the practical economy has not yet been reached of the reciprocating engine. The turbine is still an experiment.

I was in the Fifty-ninth street power station of the New York subway within the last couple of weeks. The turbine engines there are still undergoing experimentation, while the reciprocating engines of the type shown on the screen are in full operation and running as smoothly as sewing machines and doing an enormous percentage of the work. Of course, I did not intend to prophesy what is going to be done. Prophecy is a very dangerous thing in these days if you want to be a true prophet; but it is not at all demonstrated that the best practice has taken hold of the turbine engine at all.

The question of the steam economy of the turbine engine seems to be identified with rim, or circumferential speed: which means that if a small and so a machine of low first cost is produced, and this seems to be one of the vital points in steam turbines, then a very high rate of revolution is needed for high steam efficiency. But these extremely high revolutionary speeds are entirely too high for even turbine pumps, the fact that water is so uncompromising seeming to demand a certain speed of revolution in the pump to match any certain head of water. Therefore, the pump must first be made to run at a speed suited to the water column, and then the turbine steam engine directly coupled to

this pump must be made of a diameter which will give the proper rim speed of the steam turbine. And when this is done in a manner which will give as high an efficiency as the very fast revolving steam turbine, it will be found that the first cost is not so low as is so generally talked about.

And, even after the large steam turbine is put to work, speeded to suit the pump and giving a proper rim velocity for its own steam economy, it will be found that its capital account is not so favorable as now represented and expected, nor will its net efficiency result in the pumping of water so cheaply as its reciprocating rival. In a pumping station the coal account is a constant drain upon resources, no matter how cheaply the coal may be bought, and it is not at all difficult to show the balancing point between coal duty and capital invested in the pumping machinery. With equal durability, a cheap machine can not hold its own in the pumping of water unless its steam economy justifies its use. And the more expensive machine, if its steam economy warrants its use, will drive out its rival. As to complication there are very many more actual parts manufactured and placed in a turbine engine than in a reciprocating engine. But we need not worry; each type of machine will find and take its proper place in the natural fitness and economy of things.

A Member: I should like to mention a little incident that came to my attention recently; I met Mr. Ensign in Los Angeles, who has had a very great deal to do on the Pacific coast with the development particularly of high voltage long distance transmission. More recently he had charge of the installation of a 5,000 h. p. steam turbine for the Edison Company of Los Angeles, and he is very enthusiastic over that steam turbine. It is only fair to say that they combine with it the use of crude oil as fuel, which also comes into the problem; yet he had every confidence indeed in the success of the steam turbine. It has been in operation in that electric-light station for some time.

THE D'AURIA PUMPING ENGINE.

By Luigi d'Auria.

A first acquaintance with the type of non-rotative pumping engine known as the duplex direct-acting pumping engine caused me to wonder why the cylinders of this engine had no cut-off valves, and why it had to use steam so uneconomically, when the demand for the higher duty was becoming stronger every day. Inexperience at the time was, no doubt, responsible for my daring to think that this type of pumping engine needed only cut-off valves on its cylinders, and the simple mechanism necessary to operate them, in order to be raised to the rank of a high duty pumping engine, a very simple proposition indeed when everybody knew how to design cylinders with cut-off valves.

I thought that duplex direct-acting pumping engine working under steam expansion secured by cut-off valves should perform its strokes with an accelerated and retarded motion and that by eliminating the usual lost motion allowed in the mechanism moving the admission and exhaust valves, the two sides of the engine should have to follow each other as if linked to quarter cranks, because steam then could only begin to enter the cylinder of one side when the piston of the other side would reach the middle of its stroke. As far as the working of the pump is concerned, this engine would have an important advantage over a duplex fly wheel pumping engine connected with quarter cranks, because its two sides having no real connections between them would combine their motions in such a manner as to produce the least change of pressure upon the pump when the volume of air in the air chamber becomes insufficient.

What could prevent this pumping engine from working successfully if its cut-off valves were adjusted properly, so that as much work would be done in the steam end as required to balance the work done in the water end, including friction?

This was a perfectly legitimate question to ask, and the only answer I received to it, was that such a pumping engine had already been tried by leading pump manufacturers in this country with disastrous results. They had found that—direct-

acting duplex pumping engines could only work satisfactorily when the propelling force of steam and the pump resistance balance each other at every point of the stroke, and, unfortunately, this dictum had become a law which no engineer familiar with the designing and working of non-rotative pumping engines would dare to violate.

On account of the mystery which seemed to surround the problem, I made a careful mathematical analysis of the dynamics of non-rotative pumping engines, mention of which was made in the proceedings of the American Philosophical Society of Philadelphia, April 17, 1885, by Prof. Pliny Earle Chase, LL.D., in a paper entitled "The Chase-Maxwell Ratio." This analysis showed that the pumping engine under consideration, in accordance with a general formula which I had evolved, giving the plunger speed under various conditions of steam expansion, etc., would, with an early cut-off, acquire so

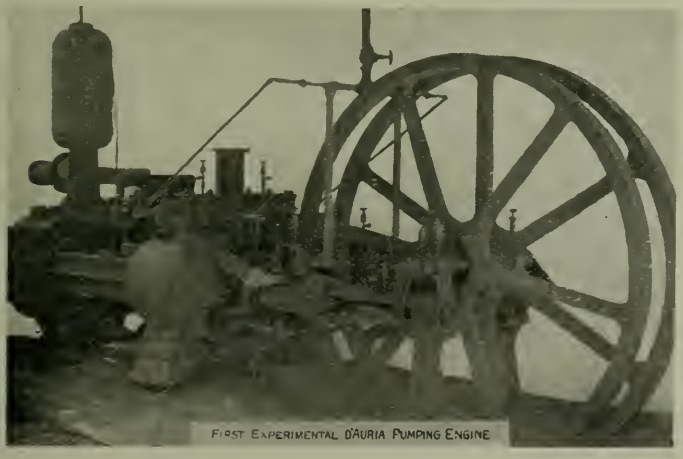


FIGURE 1.

great a speed as to make it impossible for the water in the suction pipe to even partially fill up the plunger displacement in the short time allowed for a stroke; and the evident result which would attend this action would be that on its return stroke the plunger being driven by the engine in a partial vacuum at a fearful rate of speed, would meet the liquid column already started in the suction pipe, with disastrous consequences to the engine and pump.

This serious defect being analogous to that of a watch running several times faster than it ought to, I saw that the question was one of determining a proper balance wheel for my pumping engine; and, in order to test this conclusion, and also the accuracy of the formulæ involved in the investigation, the following experiment was made:

A large, non-compound, direct-acting duplex steam pump was borrowed for the occasion, and this was temporarily compounded with two high pressure cylinders, each having a diameter less than one-third that of the low pressure cylinders. This is shown by Fig. 1. The ratio of area between the high and low pressure pistons was about one to ten, and the re-

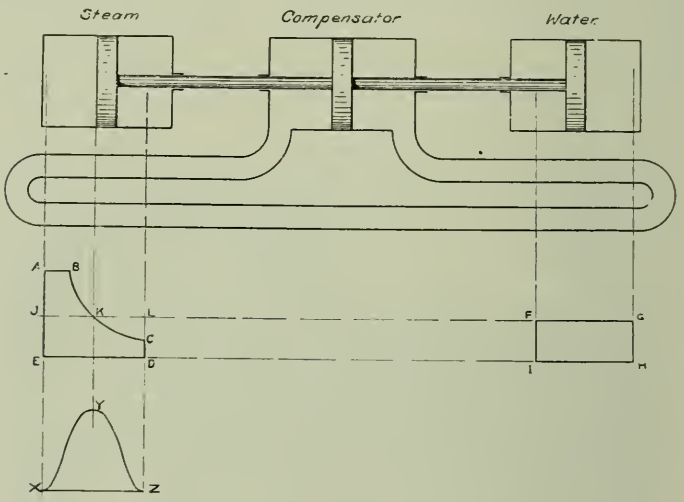


FIGURE 2.

ceiver volume was made as small as possible in order to make the combined propelling force at the beginning of the stroke considerably larger than at the end of the stroke. The piston rod of each high pressure cylinder was connected by a link to a balance wheel oscillating about sixty degrees at every stroke. This machine worked as smoothly and steadily as a large clock and proved nearly fourteen years ago that my theory could be safely relied upon.

Having done this, attention was directed to finding the best form of balance wheel for my high duty pumping engine. It

was realized that an ordinary balance wheel was open to the serious objection of twisting its shaft in case the load was suddenly relieved, beside involving a considerable amount of mechanism. My search ended when I discovered the hydraulic balance wheel or compensator, which consists mainly of a liquid column contained in a closed loop of smooth pipe extending from the ends of a suitable chamber, also completely filled with liquid, in which chamber is fitted a plunger mounted upon the same rod carrying the pump plunger and the steam piston, or pistons, of the engine. This is shown by Fig. 2. When the engine is moving the compensator plunger compels the liquid column to oscillate with a pendulum-like motion in the compensator pipe. The velocity of this liquid column depends not only upon the speed at which the engine is moving, but also upon the ratio its cross-section bears to the area of the compensator plunger. Now, during the early part of the stroke, and before steam is cut off, the energy developed by the steam end being in excess of that required by the pump, the motion of the engine is accelerated and the surplus energy is stored partly in the reciprocating parts, but mainly in the compensator column as kinetic energy. After cut-off has taken place, the propelling force of the engine becoming insufficient to overcome the resistance of the pump, this kinetic energy gradually supplies the deficiency by producing a forward pressure upon the compensator plunger during its period of retardation, with a loss of efficiency very much smaller than is incurred when a fly wheel is employed for the same purpose. When a sudden drop in the load of the engine occurs, the accumulated energy at the end of the stroke would cause a severe water-hammer in the compensator, in spite of the large amount of positive steam cushioning provided in the steam cylinder, but this is absolutely prevented by so proportioning the length of the compensator plunger that the latter begins to open a by-pass as soon as the pistons overrun their normal stroke; that is, when they are at about three-eighths of an inch from the cylinder heads. This by-pass is formed by the compensator plunger leaving its liner, and its area is sufficiently large to prevent striking of the pistons against the cylinder heads even when the load is relieved altogether.

The first pumping engine embodying the d'Auria hydraulic compensator was built in Nashville, Tenn., about eleven years ago. This is shown by Fig. 3. Its water end was bought from a pump maker, but all the rest was especially designed. There is between the water end and the steam cylinders something never seen before on a pumping engine. That is the hydraulic compensator at the ends of which there are two necks connected to quarter-bends looking towards the steam end. To these bends are screwed two lengths of ordinary wrought iron pipes, joined together by a return bend. This loop is the compensator pipe in which the liquid column oscillates. This engine is not compounded, but its steam cylinders are provided with

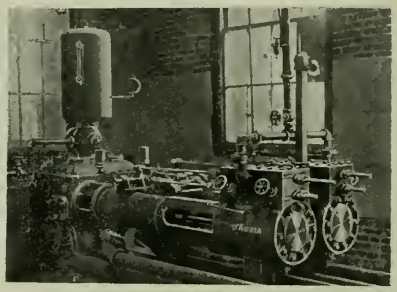


FIGURE 3.

cut-off valves placed on top of the admission and exhaust valves. The dimensions are 12-inch x 6-inch x 12-inch. This engine was provided with a tank, shown on the side of the water end, connected to the suction. This tank was kept full of water, and the pump was made to discharge into it through a small pipe and an ordinary valve. By this means, a water pressure of about 70 pounds was raised upon the pump, with steam at about 51 pounds pressure, cutting off at about one-fourth of the stroke. Under these conditions, the engine made 154 strokes per minute with astonishing smoothness and steadiness of action, one side following the other as if connected by quarter cranks.

The discharge was at a rate of over 600,000 gallons per 24 hours, without perceptible variation of pressure. The action of the by-pass in the compensator was severely tested by sud-

denly relieving the pressure upon the pump, and it always prevented the striking of the piston against the cylinder heads.

The above test of the first d'Auria pumping engine was made February 14, 1894, at Nashville, Tenn. Later on the engine was shipped to Philadelphia, Pa., where it was kept running for the purpose of exhibition, and where it was inspected by a number of engineers. The law established by the builders of non-rotative pumping engines that the propelling force of steam and the resistance of the pump in these engines must necessarily balance each other at every point of the stroke was broken. Those most interested in pumping engines, professionally, smiled, and builders of non-rotative pumping engines were so certain that an engine constructed on this new design would not work that they

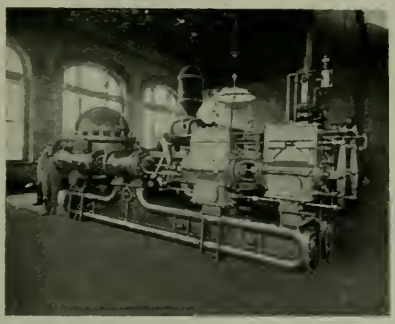


FIGURE 4.

would not even take the trouble to see it. Were it not for this skepticism, the d'Auria pumping engine would not need to be introduced to you to-night almost as a novelty, but might have invaded your Water Works perhaps ten years ago. It was fortunate that at least one man, Colonel Henry M. Robert, now Brigadier General Robert, Chief of Engineers, U. S. Army, retired, after carefully examining the new theory of non-rotative pumping engines, was convinced of its soundness and consented to assist financially not only in making the experiment with the balance wheels, but also in building the Nashville engine and a smaller one which is the smallest d'Auria pumping engine made, its di-

mensions being 6-inch x 4-inch x 6-inch, and was built at Philadelphia, Pa. It shows an improved water end, and also the compensator pipe in the shape of a bed plate. The steam end is built simple with cut-off valves.

This little machine when tested developed a duty of 26,200,000 foot pounds per one thousand pounds of wet steam running non-condensing, with a cut-off at about four-tenths of the stroke, and its action was as perfect as could be desired.

At this period, the d'Auria Pumping Engine Company was organized, with offices in Philadelphia, Pa., and there I designed the first water works d'Auria pumping engine of 3,000,000 gallons capacity in 24 hours, against a pressure of 100 pounds. This engine, which is shown by Fig. 4, was built by the I. P. Morris Company, for the d'Auria Pumping Engine

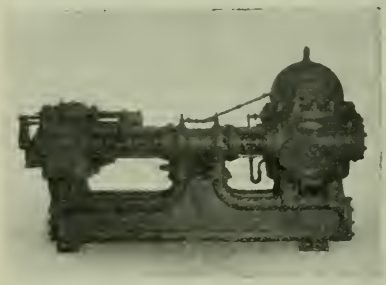


FIGURE 5.

Company. It is a compound condensing engine with cylinders 10-inch and 20-inch in diameter, and 18-inch stroke. The plungers are 10 inches in diameter and 18-inch stroke.

Before its completion an arrangement was made with the Bureau of Water in Philadelphia through its chief, John C. Trautwine, Jr., to test it at the Roxborough Auxiliary Pumping Station, although the conditions of steam and water pressures there were far from being suitable for a proper test. The photograph shows this engine in the pumping station just named. No solid foundations were provided for it, other than the engine room floor, and as you may be able to see from the picture, the engine was not even fastened to the floor, although when put into service against a water pressure of about 60 pounds, it ran at a speed of 80 revolutions per minute, or 240

feet piston speed, without vibrations in any of its parts. This same engine was later on temporarily installed at the Shawmont Pumping Station (in an emergency when a large engine had broken down) to assist in the severe service of pumping against a pressure of about 165 pounds. Here also the engine was placed on the engine room floor without any other foundations or bolting down, and when bought by the Bureau of Water, it was finally installed at the Wentz-Farm Pumping Station, with a larger water end designed to pump 4,000,000 gallons in 24 hours.

All these pumping engines were fitted with plain slide valves, perhaps owing to prejudice I had in common with European Engineers, against rotative or "Corliss" valves. The engine shown by Fig. 5 is the last engine fitted with plain slide valves. It was built for the Coplay Cement Company, Coplay, Pa. It has a capacity of about 600,000 gallons in 24 hours and is built simple with cut-off valves.

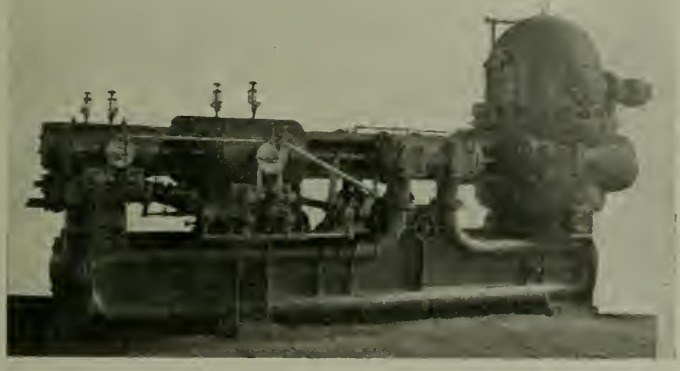


FIGURE 6.

The first change of design I made in the style of valves was on a pumping engine built for the Havana Water Works, Cuba, as shown by Fig. 6. This engine has a capacity of about one million gallons per 24 hours, against a pressure of about 100 pounds, and was built at Philadelphia, Pa. It is a compound condensing engine, fitted with admission and exhaust

valves of the rotative type, placed at the bottom of the cylinders. Below these valves in each cylinder there is a steam chest in which are fitted cut-off valves of the piston type mounted upon a stem with right and left threads to permit a change of cut-off by the turning of the stems, which can be effected while the engine is running.

A compound condensing pumping engine similar in construction to the one just shown, but of 3,000,000 gallons capacity in 24 hours, was built at Philadelphia also for the City of Atlantic City. This engine has shown its ability in service to pump nearly 4,000,000 gallons in 24 hours, and ordinarily pumps about 3,500,000 daily. It is to be regretted that on account of the closeness of the engine room, a photograph of this engine could not be taken. The cut-off valves, as well as the admission and exhaust valves in this engine, are of the rotative, or Corliss, type, and all placed at the bottom of the cylinders.

Two more pumping engines having the same steam end used in the Atlantic City engine, but smaller water ends, were built at Philadelphia and installed in the Government Hospital, Washington, D. C. A million-gallon compound condensing d'Auria pumping engine was also built for the Ocean City Water Company, Ocean City, N. J. In this engine the valves are operated without wrist plates, but the rest of the engine is the same as the Havana engine.

Two more d'Auria pumping engines, each of 1,500,000 gallons daily capacity, but of the simple type, were also built by Mr. Morris, besides several air compressors, embodying the hydraulic compensator. These machines proved that this compensator can easily take care of the large amount of accelerative work developed in the first part of the stroke of an air compressor, generally requiring very ponderous fly-wheels in rotative compressors.

Two compound condensing d'Auria pumping engines were installed in the Water Works of Cumberland, Md., through Mr. John C. Trautwine, Jr., consulting engineer for the city, and according to contract with the city were to pump each 2,000,000 gallons in 24 hours. This capacity, however, was found to be too small to meet the demand for water, and their speed was increased so as to pump nearly fifty per cent.

more water than the contract called for. These machines, with a stroke of 18 inches, are being worked every day at a speed of nearly 300 feet per minute, or nearly one hundred revolutions per minute, without being bolted to the floor.

To show how near the motion of the d'Auria engine corresponds to that of a crank and fly wheel engine, this diagram (Fig. 7) was taken from the d'Auria pumping engine installed at Atlantic City. It was traced by a pen carried by one of the piston rods, upon a roll of paper moving at right angles to the motion of the rod. This was suggested by Mr. W. C. Hawley, Gen'l Supt. of the Pennsylvania Water Company, then Engineer and Superintendent of the Water Department of Atlantic City. The apparatus was designed by his assistant, Mr. E. E. Lan-

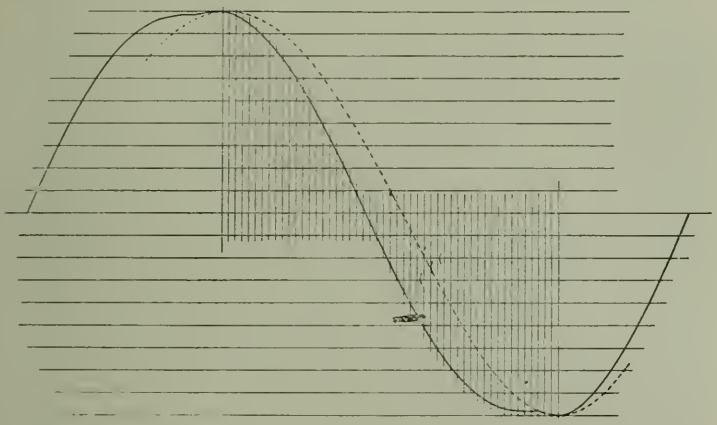


FIGURE 7.

pher, and worked quite successfully. It showed that the motion of the piston is accelerated and retarded like that of a crank and fly wheel engine, but the acceleration and retardation, especially the latter, takes place more gradually,—that is, is more lingering in the d'Auria engine than in the crank and fly wheel engine. This peculiarity of motion of the d'Auria engine permits the pump valves to fall upon their seats quietly, touching them the instant the plunger is at the end of its stroke, and to this is due the fact that the slip through the valves in the d'Auria pump is small. This was already found out with the

pumping engine installed temporarily at the Roxborough station, Philadelphia, Pa., by some readings of the Venturi Meter, but Mr. Hawley brought it out by a more prolonged and accurate test with the pumping engine installed at Atlantic City, pumping through a Venturi Meter.

"We recently made a duty test of our new d'Auria pumping engine which is an outside packed plunger machine, of course, with new valves and hence very little possibility of 'slip.' I had personally adjusted the Venturi Meter register and am pleased to say that the registration of the Venturi Meter was .35 of one per cent. less than that of the pump on a twenty-four hour test. The length of stroke was taken every fifteen minutes so that slight variations in length of stroke between these times

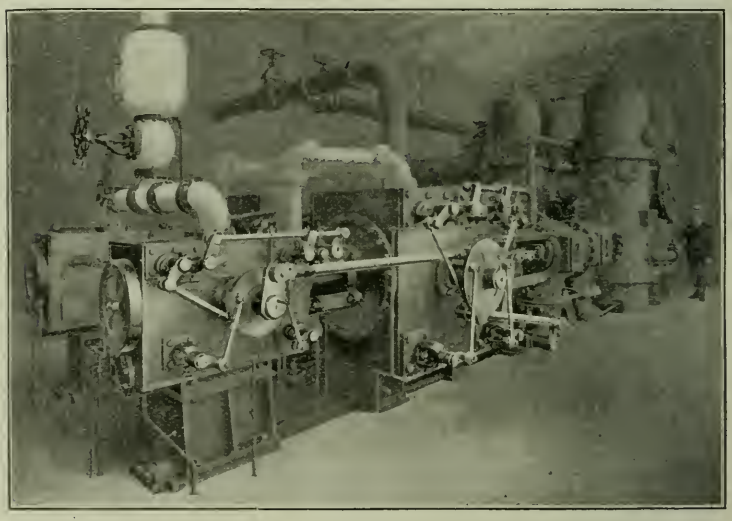


FIGURE 8.

might easily account for the difference in registration. Needless to say we are very much pleased with the Venturi Meter and also that we have a pump that gives such small slip."

A contract was secured by the builders for a ten million gallon d'Auria pumping engine for the New Haven Water Company, New Haven, Conn., to work against a water pressure of 75 pounds per square inch, with a steam pressure of

150 pounds per square inch. The design of this engine differs from that of the pumping engines previously built only

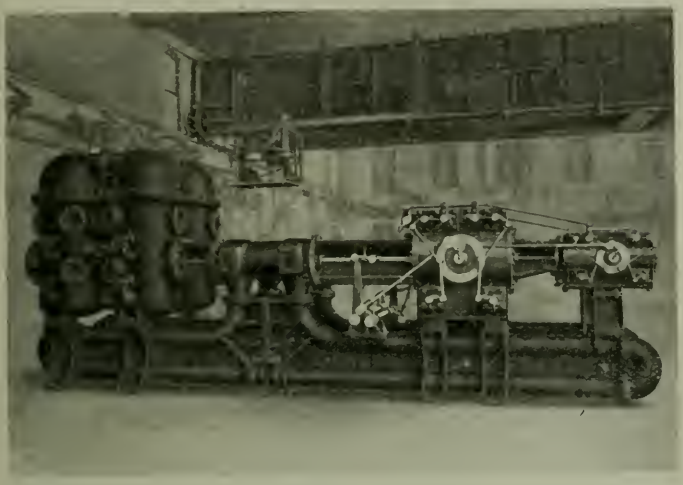


FIGURE 9.

in one particular, and that is, in the New Haven engine the cylinders have admission and exhaust valves separated from

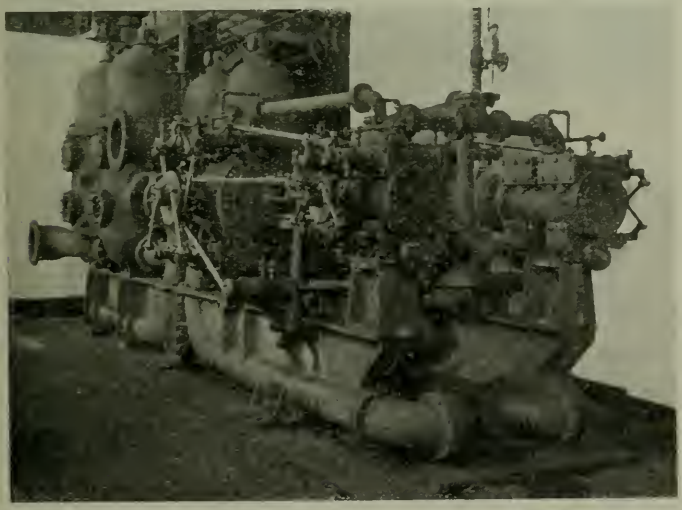


FIGURE 10.

each other as in Corliss cylinders. The cut-off valves are

independent of the admission valves as in previous engines, and can be adjusted by hand while the engine is running. The engine is tandem compound, with cylinders 14 inches and 32 inches in diameter and a stroke of 30 inches. The plungers are 18 inches in diameter, with 30-inch stroke. This engine has just been installed and put into service.

Fig. 8 is a photograph of this pumping engine as it appears in the station. The compensation pipes are not seen as they are below the floor level.

Fig. 9 is a photograph (taken in the machine shop) of a pumping engine now being erected at the waterworks af Mari-

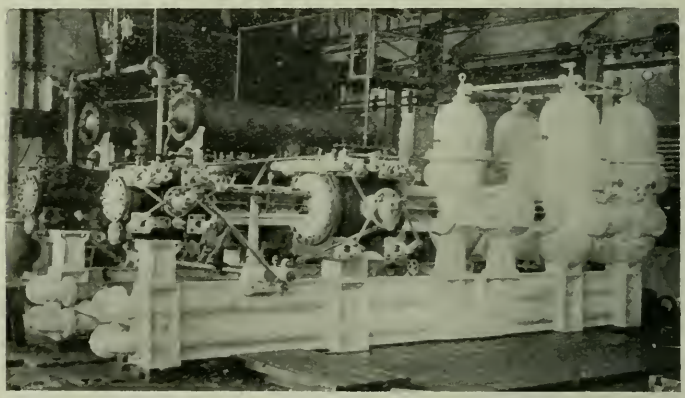


FIGURE 11.

etta, Ohio. This pumping engine has a capacity of 4,000,000 gallons in 24 hours, against a pressure of 105 pounds per square inch, and has just been installed. Its cylinders are 12 and 28 inches in diameter, with a stroke of 24 inches.

Fig. 10 is a photograph of a pumping engine of about 2,200,000 gallons daily capacity, against a pressure of 130 pounds per square inch, which is now being installed in the Sayles Bleacheries, Saylesville, R. I.

Fig. 11 is a photograph of a pumping engine now being erected at the pumping station of the Dedham Water Company, Dedham, Mass., and is the first one built with a duplex hydraulic compensator to meet the demand of Mr. Percy M. Blake, consulting engineer, who desired that the engine should

be able to work with practically the same number of expansions under widely different rates of pump discharge, against the same water pressure. This duplex hydraulic compensator consists of two columns of water oscillating in two loops of pipe, communicating with the ends of each compensator chamber. One of these loops is furnished with a valve which, when shut, allows all the water displaced by the compensator plunger to flow through the other loop. By this means the speed of the

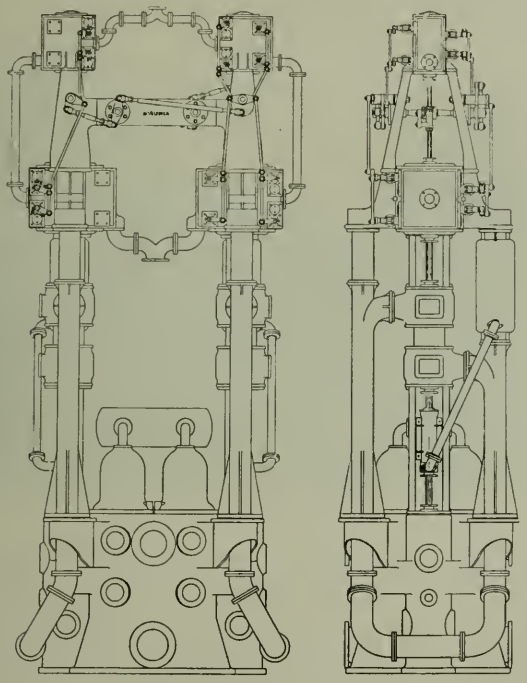


FIGURE 12.

engine is reduced to its minimum without changing the cut-off in the steam cylinders. The maximum speed is had when the valved loop is full open, and intermediate speeds are secured by properly adjusting the position of the valve in this pipe. It may be well to state that the change of speed thus obtained is not due to friction but simply to change of momentum of the hydraulic compensator.

Fig. 12 shows general design of the first vertical engine built. This engine is nearly ready for test in the shop, and was built for the city of Brandon, Canada. Its capacity is about 2,500,000 gallons per 24 hours. In this design there has been used the compensator pipes as columns for the support of the steam cylinders, making a very compact, self-contained machine.

Fig. 13 shows the smallest compound condensing d'Auria pumping engine built. Its capacity is one million imperial gallons per 24 hours, against a water pressure of 110 pounds

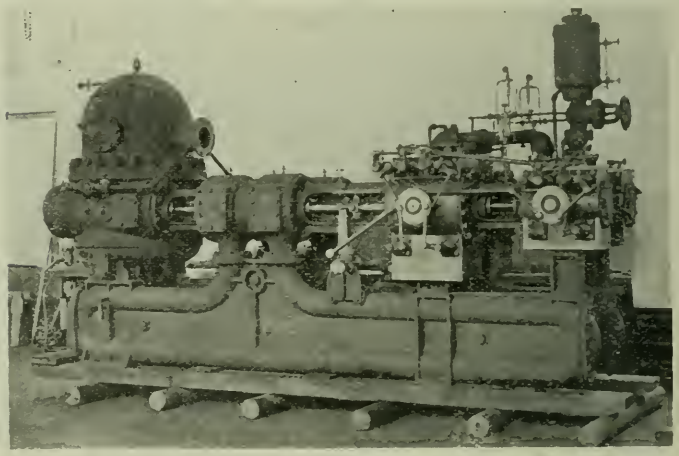


FIGURE 13.

per square inch. It is now on the way to its destination, Moose Jaw, Canada. Its cylinders are 8 and 16 inches in diameter with 12 inches stroke, both fitted with cut-off valves, and in every respect similar in construction to the cylinders of the larger engines shown. It was sold with a guarantee of 80,000,000 foot pounds duty per 1,000 pounds of dry steam furnished to the engine, a high enough duty for so small an engine, but when recently tested in the Mechanical Department of Brown University by Professor W. H. Kenerson, under nearly contract conditions, it developed a duty of over 96,000,000 foot pounds per 1,000 pounds of steam used by the engine. Professor Kenerson, on request, made a variety of tests with the engine in question, under different

conditions, all embodied in his report which will shortly be ready for distribution.

The above result obtained with so small an engine, and which, it is believed, is a record for engines of that size, is an indication that with larger pumping engines of this type the duty will be as high as claimed for crank and fly wheel pumping engines. You all know that in a pumping engine the duty is what the engine proper gives, less the amount which goes for friction of mechanism and for loss of pumpage due to slip. Now, repeated tests have shown that in these pumping engines the friction loss and that due to slip are very small, and the question of high duty is simply a matter of a well designed steam end. As the hydraulic compensator does not in the least interfere with the grade of steam expansion which may be desired to carry in the steam cylinders, nor with the point of cut-off in these cylinders, it ought to be clear that high duty with this engine is as obtainable as with the best crank and fly wheel pumping engine. The writer is of the opinion that crank-shafts and fly wheels are things which do not properly belong to reciprocating pumping engines which, rightly, should work in accordance with the laws governing the action of a pendulum. The fly wheel in a reciprocating pumping engine can do no more than the hydraulic compensator does in the matter of storing up and giving out energy in every stroke, but the trouble with the fly wheel is in the larger initial charge of energy it receives in order to keep up its rotation with a reasonable degree of uniformity. This energy in the case of a sudden break in the suction or discharge may become a dangerous quantity in the problem, and it may even cause the breaking of the engine. With the hydraulic compensator, when an accident like this occurs, the liquid column can only be charged with an amount of energy sufficient to finish a single stroke under ordinary conditions, and the by-pass of the compensator can take care of this energy with perfect safety.

Perhaps some of you may experience some difficulty in understanding how the liquid column of this form of compensator comes gradually to rest at the end of the stroke, with very much reduced speed, and yet it is there that the engine requires the greatest assistance in finishing the stroke. You

are no doubt familiar with the action of the high duty attachment, used on the Worthington pumping engines, and know that the compensating plungers at the end of the stroke are in their best condition to produce a pull upon the pump rod. How is it then that the d'Auria compensator can furnish its greatest assistance to the propelling force of the engine when its kinetic energy is almost *nil,* that is, at the end of the stroke? This, perhaps, is a legitimate question, and has been often asked by well informed engineers. Suppose you take a heavy pendulum and allow it to oscillate in a given arc, or stroke. You will notice that in the ascending part of the stroke the velocity of the pendulum and its kinetic energy become less and less as the weight of the pendulum becomes more and more unbalanced statically. To fix the idea, suppose you mark the position when the pendulum is at one-hundredth of an inch from the end of the ascending stroke, where, you know, it would require the most help from your hand to hold it there, and where its velocity is almost zero. You cannot doubt the fact that the pendulum when passing this position has still sufficient energy not only to hold itself there for an instant, but

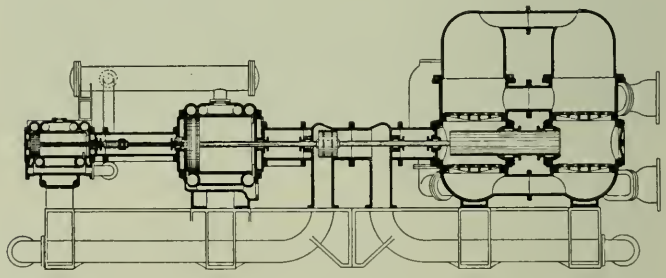


FIGURE 14.

to actually move up another hundredth of an inch against the maximum gravitational tendency to force it down. This is not a miracle, but a fact, which I believe explains very simply the action of this hydraulic compensator at the end of the stroke. It explains also why a pumping engine of this type can be run at a high speed without its being fastened to the floor, and without vibrations in any of its parts.

There is now a ten million gallon d'Auria pumping engine in course of erection at Allentown, Pa., for the City of Allentown, Pa.

Work on several other pumping engines has been started, among others a five million-gallon pumping engine for the City of Meriden, Conn., recently contracted for.

Fig. 14 shows a longitudinal section of a pumping engine, showing arrangement of valves, etc. The valve decks in the water end are cast in steel and, of course, are separated from the main casting. This arrangement is used in all pumping engines exceeding one and a half million gallons capacity.

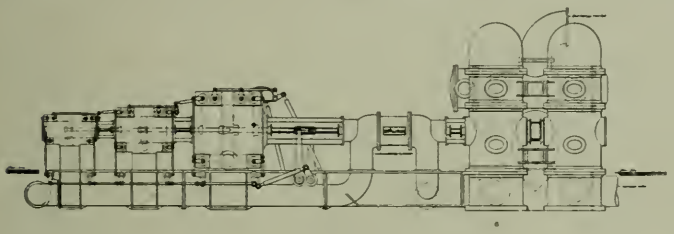


FIGURE 15.

Fig. 15 shows the general design of a triple expansion pumping engine of about 1,200 horse power. In this design the valves are operated without wrist plates, and this method has now been adopted for pumping engines of all sizes.

DISCUSSION.

Mr. Hague: I have been familiar with the d'Auria pumping engine for about five years. The first one I saw was one of those shown on the screen at the Shawmut station in Philadelphia. It was operating at 140 pounds water pressure, and steam at about 100 pounds. The engine was working very rapidly and absolutely noiselessly. The general design I thought exceptionally good from a mechanical standpoint. The castings were well designed, with the fillets and round corners that were looked for in first class work. As far as I could see this engine, if properly placed upon a commercial basis and pushed with the energy with

which some of the others have been handled, would no doubt get its share of business. It has the peculiarity of the high-duty type of direct-acting machines, inasmuch as the point of cut-off is changed very little at different speeds. In that respect the direct-acting machines differ from crank and fly-wheel engines in which the slowing of the fly-wheel often makes it necessary to extend the point of cut-off. The different engines shown on the screen exhibit a short stroke and pretty large clearance or waste room. Outside of that particular I do not see why it cannot be developed into a pumping engine which will at least equal any other carried to the same perfection of detail.

This matter of clearance is a very important one and seems either not to have received proper attention, or it may be in the construction of that sort of machine that it is impossible to reduce the clearance to such a fine point; as the close clearance on a direct-acting engine and without being controlled by a wheel would be apt to make the action rather sharp at the ends of the stroke. It has always been a question in my mind whether the non-rotative pumping engine can be brought to the point of as close clearance as the fly-wheel engine. It is very doubtful whether the direct-acting machine can reach the high duty and mechanical efficiency combined of the fly-wheel type.

The question of a breakdown, which is mentioned in the paper, is hardly worth dwelling upon. Most pumping engines of fair construction under proper care operate for long periods of time with very little expense for repairs compared with the work done.

After all, the steam efficiency of this engine will probably depend upon how fine a point the clearance in the steam end can be brought down to.

Mr. d'Auria: While admitting with Mr. Hague in a general way that clearance affects the economy of an engine, I would say that the amount of steam saved in an engine practically without clearance over one with a clearance of 3 per cent. or 4 per cent., other things being the same, is hardly appreciable, especially in compound and triple expansion engines. The amount of clearance in d'Auria pumping engines of larger

sizes, is brought down to about 3 per cent. or 4 per cent., and it can be made less if desired.

A small compound d'Auria pumping engine of one million gallons capacity was recently tested at Brown University by Prof. W. H. Kenerson. This engine has 12 inches stroke and gave a duty of 96,765,000 foot pounds per 1,000 pounds of dry steam. In order to find out how much this duty would be reduced by a large increase of clearance space, the engine was made to run with 11 inches stroke instead of 12 inches stroke, and the duty obtained was 86,190,000 foot pounds per 1,000 pounds of dry steam.

Considering the fact that the reduced stroke, besides increasing the clearance, also destroyed all cushioning and compression at the end of stroke, the difference in duty is not alarming, showing that small differences in clearances can hardly affect the duty appreciably.

The d'Auria pumping engine which Mr. Hague saw at the Shawmont Pumping Station in Philadelphia was sent there from Roxborough on account of a breakdown of a large crank and fly-wheel pumping engine at the former station. This engine had a capacity of 3,000,000 gallons per diem against a pressure of 100 pounds. It was rolled down a hill and was laid on the engine room floor without bolting down. It was made to work against a water pressure of 165 pounds, although only designed for 100 pounds pressure. The machine performed its service there for several months and then was removed to another pumping station.

I would like to ask if any one present has ever known of a high-duty pumping engine of such capacity that could be moved from station to station as if it were a portable machine? The fact that the d'Auria engine can run at a high rate of speed without vibration and without being bolted to the floor is of more significance than the mere fact of a saving in the cost of foundations. It bespeaks quietness of action and long life. Other engines may appear to be working quietly when fastened to their ponderous foundations by heavy bolts, but quietness under such a condition is like the tranquility of a maniac put in a strait-jacket. The d'Auria pumping engine requires neither to be bolted down nor to be placed on a solid

foundation. A floor capable of supporting its weight is all that is necessary.

BOOKS FOR THE WATER-WORKS OFFICE.

By M. N. Baker, Associate Editor "Engineering News," Editor "Engineering Literature Supplement."

Not many years ago the library of a water-works office began and ended, if indeed it began at all, with Fanning's "Water Supply." That monumental work was for some years practically the only American book designed for water-works engineers and superintendents and was quite generally thought to meet all their needs. Since Fanning's treatise appeared many other books specifically designed for water-works men have been published. Meanwhile the scope and magnitude of the duties of water-works officials have so enlarged that many books outside the specific field of water-works literature are needed for a well-equipped water-works office. Certain as is this need, how frequently is it recognized and supplied? In how many water-works offices would there be found at this minute a dozen good books on water-works and even one on any of the numerous closely allied topics?

It is easy enough to explain, but the explanations do not wholly excuse, the smallness of the libraries of most water-works offices. Some of the reasons why more books are not in use are: (1) Lack of appropriations for the purchase of books; (2) lack of interest in books because of the too frequently short tenure of office; and (3), most valid of all explanations, the almost absolute lack of books on maintenance and operation. A little zeal for a water-works library would, in most instances, secure at least a small yearly sum for the purchase of books. The frequent short tenure of office makes the need of a library all the greater. The lack of books on maintenance and operation might be overcome if some of the many capable and experienced superintendents, secretaries and treasurers would reduce to writing their wealth of knowledge on these subjects.

When I was invited to present a paper to this convention, my first plan was to pass in review some of the leading water-works books and stop with them. On reflection it has seemed advisable to substitute for such a review as complete a list as I could prepare of all the distinctively water-works books published in this country and add to that list a considerable number

on more or less closely allied subjects. Aside from adding very brief comments on a few books or groups of books, partly to explain why they are included, I shall leave the task of specific criticism to the members of the Association. If a liberal response is made to the invitation thus extended, and particularly if titles of books are suggested for addition or for omission, I may be encouraged to take up, at a later date, a more specific criticism of some of the books. No one person, it is evident, can be expected to pass valid judgment on each book in so long a list, which is one reason why I have not undertaken the task. Another reason is that the preparation of the list, and the comments which precede it, has absorbed all the time at my disposal prior to the date of submitting the paper to the printers. This Association as a whole is competent to criticise ably every book in the list, and I submit that such a body of criticism would be of great value to the profession, and also to the authors and publishers of future books on these and related topics.

As has already been stated, I have aimed to include in the appended list all American books known to me that deal specifically with water-works; or perhaps I should say, all general water-works books and most of the books dealing specifically with some distinct phase of water-works. Naturally the list is headed by the most general or inclusive books, which are five in number.

Turneaure and Russell's "Public Water Supplies" is placed first because of its comparative recentness, comprehensive character and extended bibliographies at the end of the chapters.

Fanning is fifth in the list because of its need of revision.

Folwell's "Water Supply Engineering" is a smaller book than Turneaure's, and lacks the bibliographies (although it has references in the text), but it is a useful work.

Goodell's "Water-Works for Small Cities and Towns" is valuable for large works as well as small. It contains numerous citations from well-known engineers on questions of design and construction and is well worth buying even by those who generally limit themselves to one book to a topic.

Gould's "Elements of Water Supply Engineering" has been produced by successive additions of other matter from the late

author's earlier "Practical Hydraulic Formula."

A few of the other books near the head of the list may be mentioned briefly, as follows:

Mead's "Notes on Hydrology" is the most recent of the books on water supply, as contrasted with the broader subject of water-works, and is valuable for its many diagrams and full bibliographical lists.

Billings' "Details of Water-Works Construction" deals almost wholly with pipe-laying and though rather old it is the most complete presentation of the subject available.

Meyer's "Water Waste Prevention" is older still and is not representative of present American practice, but it is nevertheless of value.

Both Hill and Mason confine themselves more particularly to questions affecting the quality of water.

Wilson's "Irrigation Engineering" has much in common with the general books on water-works, and is particularly valuable for Western men.

Of the next fourteen books nothing need be said, since their titles indicate their general scope sufficiently. Going on down the list, only an occasional book will be mentioned here.

Schuyler's "Reservoirs" is largely descriptive of quite a range of Western practice, including rock-fill and hydraulic-fill dams.

Wegmann's "Dams" is a standard technical work.

Hazlehurst's "Tanks and Towers" contains practically nothing on wood stave tanks.

Beginning with Johnson's "Surveying" about twenty books are given, all of which will be useful in large offices and from which selections can be made for small offices. It will be seen that these books deal with methods of doing work, materials of construction, contracts and specifications and other legal points.

There is no satisfactory book on plumbing, but Gerhard's "Sanitary Engineering of Buildings" and Clark's "Care of the House," taken together, go far towards filling the gap. Clark's book is cram full of practical information on the selection and care of plumbing and heating apparatus, woodwork and other parts of a building and its equipment.

Wait's "Law of Operations Preliminary to Construction" should be particularly valuable to water-works men because it

deals at length with water rights and allied subjects, the condemnation of land, and municipal franchises.

Something on geology, meterology and physics should certainly be found in all the larger water-works offices.

The books on forestry are suggested in view of the reforesting of drainage areas already begun by a number of water-works and the desirability of extending such work. The book on identifying trees is useful and suggestive, and the one on species of wood is even more practical in character.

The creditable desire of water-works officials to beautify the grounds around their pumping stations and reservoirs suggests the need for a book on landscape architecture or gardening. The smaller of the two books by Parsons contains much that is in the larger one and is handier and cheaper. It would be particularly useful in planning the improvement of relatively small grounds around pumping stations and keepers' cottages, besides being of use to any one having private grounds.

The esthetic improvement of cities as a whole should appeal to all classes of city officials and to all public service or franchise companies. This subject is ably treated in the two books, near the end of the list, by Robinson. The first and smaller of the two deals with some of the more practical aspects of the subject, such as orderliness, convenience and cleanliness which should receive attention before beautification without ridiculous contrasts is possible. The book on judging architecture will be useful both in connection with the general problem of municipal esthetics and as an aid to forming a correct taste for judging the architectural merits and demerits of proposed buildings for water-works purposes.

The last six books named, like those by Robinson, also deal with general municipal problems, and like Robinson's are inserted because the water-works official should never forget that he is a part of the municipal whole and as such should try to be informed on all those subjects affecting the city at large which come within his range of possible influence. The first of the six books, Whinery's "Municipal Public Works," however, contains many facts and suggestions bearing directly and indirectly upon the water-works department. My own little book on "Municipal Engineering and Sanitation," named earlier in

the list, discusses some of the questions taken up by Mr. Whinery and in addition many general phases of municipal government, including charters, boards of public works, and uniform municipal accounting. There are a number of good books on municipal government which might be included in the list, but of these only Wilcox's "American City" and Shaw's two books have been inserted. Wilcox's book is given because in it, as its sub-title indicates, the relation of city growth to democratic institutions is considered. Shaw's books are mentioned because every municipal official should know something of the way municipal works are conducted abroad.

Bemis' "Municipal Monopolies" and Darwin's "Municipal Trade," the latter being a British book, present the two sides of the municipal ownership question in detail. Most of the arguments and statistics in Bemis are designed to prove the superiority of municipal ownership. Darwin presents arguments (he gives few or no statistics) on both sides, but on the whole he is strongly in favor of private ownership, except for water-works.

It may have been noticed by some that my list contains no book on water-works finance, accounting or office management. With more time at my disposal, doubtless something more or less adaptable to water-works needs could have been found on accounting and on office management. I trust to the members of the Association to supply the deficiency. The broader phases of municipal accounting, with special reference to uniformity, have been under consideration for a number of years by a committee of the National Municipal League (Chairman, Edward M. Hartwell, Secretary Statistics Department, Boston, Mass.).

In conclusion, I wish to return to a subject mentioned earlier in this paper: the lack of books on water-works management. With the possible exception of some books for stationary engineers and firemen, which I have not attempted to look up, there is practically nothing on the management of water-works. This lack is quite in keeping with one of the most notable features of American municipal government, the often lavish expenditure for constructing public works and the frequent niggardly appropriations for repairs and maintenance. Probably water-works have suffered less in this particular than most

municipal works, because water-works produce revenue and are often in the hands of independent departments which take pride in keeping them in first-class condition. Be this as it may, a comprehensive book on water-works management and operation, or a series of such books on separate branches of the subject, is one of the greatest needs of the water-works man. What can and will this Association, as a whole and through its individual members, do to make good the deficiency?

PUBLIC WATER SUPPLIES.—Requirements, Resources, and the Construction of Works. By F. E. Turneaure, C. E., Professor of Bridge and Sanitary Engineering, University of Wisconsin, and H. L. Russell, Ph. D., Professor of Bacteriology, University of Wisconsin. With a Chapter on Pumping-Machinery by D. W. Mead, C. E., M. Am. Soc. C. E., Etc.. New York: John Wiley & Sons. London: Chapman & Hall, Ltd. Cloth; 6 x 9 ins.; pp. 746; 101 tables and 231 illustrations. $5.

WATER-SUPPLY ENGINEERING.—The Designing, Construction, and Maintenance of Water-Supply Systems, Both City and Irrigation. By A. Prescott Folwell, M. Am. Soc. C. E., Associate Professor of Municipal Engineering, Lafayette College. Second Edition, Revised and Enlarged. New York: John Wiley & Sons. London: Chapman & Hall, Ltd. Cloth; 6 x 9 ins.; pp. 576; 79 tables, 19 plates, and 95 text illustrations. $4.

WATER-WORKS FOR SMALL CITIES AND TOWNS.—By John Goodell. New York: The Engineering Record. Cloth; 6 x 9 ins.; pp. 286; tables, and 53 figures in the text. $2.

THE ELEMENTS OF WATER-SUPPLY ENGINEERING.—By E. Sherman Gould, M. Am. Soc. C. E. New York: The Engineering News Publishing Co. Cloth; 6 x 8¾ ins.; pp. 168; three tables, and 29 figures in the text. $2.

A PRACTICAL TREATISE ON HYDRAULIC AND WATER-SUPPLY ENGINEERING.—Relating to the Hydrology, Hydrodynamics, and Practical Construction of Water-Works in North America. By J. T. Fanning, M. Am. Soc. C. E. Seventh Edition, Revised, Enlarged, and New Tables and Illustrations Added. New York: D. Van Nostrand Co. Cloth; 6 x 9¼ ins.; pp. 644; 121 tables and 225 illustrations. $5.

NOTES ON HYDROLOGY.—And the Application of its Laws to the Problem of Hydraulic Engineering. By Daniel W. Mead, M. Am. Soc. C. E., Professor of Hydraulic and Sanitary Engineering, University of Wisconsin. Chicago: The Author. Cloth; 6 x 9¼ ins.; pp. 202; 43 tables, 19 maps, and 46 text illustrations. $2.

SOME DETAILS OF WATER-WORKS CONSTRUCTION.—By William R. Billings, Superintendent of Water-Works at Taunton, Mass. (From 1879 to 1888.) With Illustrations from Sketches by the Author. Second Edition. New York: The Engineering Record. Cloth; 6 x 9 ins.; pp. 96; 28 figures in the text. $2.

WATER-WASTE PREVENTION.—Its Importance and the Evils Due to Its Neglect. With an Account of the Methods Adopted in Various Cities in Great Britain and the United States. By Henry C. Meyer, Editor of The Sanitary Engineer. With an Appendix. New York: The Sanitary Engineer (now the En-

gineering Record, or McGraw Publishing Co.). Cloth; 6 x 9 ins.; pp. 70; three figures in the text. $1.

THE PURIFICATION OF PUBLIC WATER SUPPLIES.—By John W. Hill. M. Am. Soc. C. E. New York: D. Van Nostrand Co. Cloth; 6 x 9¼ ins.; pp. 304; tables, and 32 figures in the text. $3.

WATER-SUPPLY.—(Considered Principally from a Sanitary Standpoint.) By William P. Mason, Professor of Chemistry, Rensselaer Polytechnic Institute. Third Edition, Rewritten. New York: John Wiley & Sons. London: Chapman & Hall, Ltd. Cloth; 6 x 9 ins.; pp. 448; illustrated. $4.

WATER AND PUBLIC HEALTH.—The Relative Purity of Waters from Different Sources. By James H. Fuertes, M. Am. Soc. C. E. New York: John Wiley & Sons. London: Chapman & Hall, Ltd. Cloth; 5 x 7½ ins.; pp. 75; 70 illustrations. $1.50.

PRINCIPLES OF SANITARY SCIENCE AND THE PUBLIC HEALTH.—With Special References to the Causation and Prevention of Infectious Diseases. By William T. Sedgwick, Ph. D., Professor of Biology and Lecturer on Sanitary Science and the Public Health in the Massachusetts Institute of Technology, Boston. New York: The Macmillan Co. London: Macmillan & Co., Ltd. Cloth; 6 x 9 ins.; pp. 368; folding and other plates. $3.

MUNICIPAL ENGINEERING AND SANITATION.—By M. N. Baker, Ph. B., C. E., Associate Editor of "Engineering News." New York: The Macmillan Co. London: Macmillan & Co., Ltd. Cloth; 5 x 7½ ins.; pp. 317. $1.25.

POTABLE WATER AND METHODS OF DETECTING IMPURITIES.—By M. N. Baker, Ph. B., C. E., Associate Editor "Engineering News," Editor "The Manual of American Water-Works." New York: D. Van Nostrand Co. Boards; 4 x 6 ins.; pp. 97. 50 cts.

INDUSTRIAL USES OF WATER.—By H. de la Coux, Chemical Engineer, Expert to the Council of the Prefecture of the Seine, Professor of Applied Chemistry, etc. Translated from the French and Revised by Arthur Morris. London: Scott, Greenwood & Co. New York: D. Van Nostrand Co. Cloth; 6½ x 10 ins.; pp. 354; 135 figures in the text. $4.50 net.

EXAMINATION OF WATER.—(Chemical and Bacteriological.) By William P. Mason, Professor of Chemistry, Rensselaer Polytechnic Institute. Second Edition, Revised. New York: John Wiley & Sons. Cloth; 6 x 9 ins.; pp. 131. $1.25.

ELEMENTS OF WATER BACTERIOLOGY.—With Special Reference to Sanitary Water Analysis. By Samuel Cate Prescott, Assistant Professor of Industrial Biology, and Charles-Edward Amory Winslow, Instructor in Sanitary Bacteriology, in the Massachusetts Institute of Technology. New York: John Wiley & Sons. London: Chapman & Hall, Ltd. Cloth: 5 x 8 ins.; pp. 162; tables, and one figure in the text. $1.25.

AN INTRODUCTION TO THE BACTERIOLOGICAL EXAMINATION OF WATER.—By W. H. Horrocks, Assistant Professor of Military Hygiene, Army Medical School, Netley; Major Royal Army Medical Corps. London: J. & A. Churchill. Cloth; 6 x 9 ins.; pp. 300; five plates. $1.20.

THE MICROSCOPY OF DRINKING-WATER.—By George Chandler Whipple. Biologist and Director of Mt. Prospect Laboratory, Department of Water Supply, Brooklyn, N. Y. New York: John Wiley & Sons. London: Chapman & Hall, Ltd. Cloth; 6 x 9¼ ins.; pp. 300; 19 plates and 21 text illustrations. $3.50.

THE MICROSCOPICAL EXAMINATION OF POTABLE WATER.—By George W. Rafter, Member of the Rochester Academy of Science. New York: D. Van Nostrand Co. Boards; 3¾ x 6 ins.; pp. 160; folding and other tables, and two figures. 50 cts.

MICRO-ORGANISMS IN WATER.—Their Significance, Identification and Removal, Together with an Account of the Bacteriological Methods Employed in their Investigation. Specially Designed for the Use of Those Connected with the Sanitary Aspects of Water-Supply. By Prof. Percy Frankland, Ph. D., B. Sc. (Lond.), and Mrs. Percy Frankland. London and New York: Longmans, Green & Co. Cloth; 6 x 9 ins.; pp. 532; two plates and 28 text illustrations. $5.

AIR, WATER AND FOOD.—From a Sanitary Standpoint. By Ellen H. Richards and Alpheus G. Woodman, Instructors in Sanitary Chemistry, Massachusetts Institute of Technology. New York: John Wiley & Sons. London: Chapman & Hall, Ltd. Cloth; 6 x 9 ins.; pp. 226; tables, and 12 illustrations. $2.

ELEMENTS OF APPLIED MICROSCOPY.—A Text-Book for Beginners. By Charles-Edward Amory Winslow, Instructor in Industrial Microscopy and Sanitary Biology in the Massachusetts Institute of Technology. New York: John Wiley & Sons. London: Chapman & Hall, Ltd. Cloth; 5 x 7½ ins.; pp. 183; 60 figures in the text. $1.50.

THE FILTRATION OF PUBLIC WATER-SUPPLIES.—By Allen Hazen, M. Am .Soc. C. E. Third Edition, Revised and Enlarged. New York: John Wiley & Sons. London: Chapman & Hall, Ltd. Cloth; 6 x 9 ins.; pp. xii+321; tables, plates, and 35 text illustrations. $3. English price, 12s. 6d.

WATER-FILTRATION WORKS.—By James H. Fuertes, M. Am. Soc. C. E. New York: John Wiley & Sons. Cloth; 5 x 8 ins.; pp. xviii + 283; 45 figures and 20 half-tone plates. $2.50.

REPORT ON THE INVESTIGATIONS INTO THE PURIFICATION OF THE OHIO RIVER WATER AT LOUISVILLE, KENTUCKY.—Made to the President and Directors of the Louisville Water Company. By George W. Fuller, Chief Chemist and Bacteriologist to the Louisville Water Company. New York: D. Van Nostrand Co. Cloth; 9½ x 12 ins:; pp. 461; tables, and eight plates. $10.

RESERVOIRS FOR IRRIGATION, WATER-POWER, AND DOMESTIC WATER-SUPPLY.—With an Account of Various Types of Dams and the Methods and Plans of their Construction. Together with a Discussion of the Available Water-Supply for Irrigation in Various Sections of Arid America; the Distribution, Application, and Use of Water; the Rainfall and Run-off, the Evaporation from Reservoirs; the Effect of Silt upon Reservoirs, etc. By James Dix Schuyler, M. Am. Soc. C. E., M. Inst. C. E., etc. New York: John Wiley & Sons. London: Chapman & Hall, Ltd. Cloth; 7 x 10½ ins.; pp. 414; tables, 25 plates, and 183 figures. $5.

THE DESIGN AND CONSTRUCTION OF DAMS.—Including Masonry, Earth, Rock-fill, and Timber Structures, also the Principal Types of Movable Dams. By Edward Wegmann, C. E., M. Am. Soc. C. E., Author of "The Water-Supply of the City of New York, 1658-1895." Fourth Edition, Revised and Enlarged. New York: John Wiley & Sons. London: Chapman & Hall, Ltd. Cloth; 9½ x 12 ins.; pp. 250; 24 tables, 95 plates, and 75 text illustrations. $5.

EARTH DAMS.—A Study. By Burr Bassell, M. Am. Soc. C. E. New York: The Engineering News Publishing Co. Cloth; 6 x 9 ins.; pp. vi+70; 31 illustrations in the text. $1.

TOWERS AND TANKS FOR WATER-WORKS.—The Theory and Practice of Their Design and Construction. By J. N. Hazlehurst, M. Am. Soc. C. E., M. Louisiana Engineering Society. Second Edition, Revised and Enlarged. New York: John Wiley & Sons. London: Chapman & Hall, Ltd. Cloth; 5¾ x 9 ins.; pp. 325; illustrated. $2.50.

IRRIGATION ENGINEERING.—By Herbert M. Wilson, M. Am. Soc. C. E., Geographer and Former Irrigation Engineer, U. S. Geological Survey. Fourth Edition, Revised and Enlarged. New York: John Wiley & Sons. London: Chapman & Hall, Ltd. Cloth; 6 x 8 ins.; pp. 573; many tables, 41 plates, and 142 figures in the text. $4.

WATER-POWER.—An Outline of the Development and Application of the Energy of Flowing Water. By Joseph P. Frizell, M. Am. Soc. C. E., Member Boston Society of Civil Engineers. New York: John Wiley & Sons. London: Chapman & Hall, Ltd. Cloth; 6 x 9¼ ins.; pp. 563; 26 tables, and 233 figures in the text. $5.

STEAM POWER PLANTS: Their Design and Construction.—By Henry C. Meyer, Jr., M. E. New York: McGraw Publishing Co. Cloth; 6 x 9 ins.; pp. 159; 16 folding plates, and 65 figures in the text. $2.

THE MECHANICAL ENGINEERING OF POWER PLANTS.—By Frederic Remsen Hutton, E. M., Ph. D., Professor of Mechanical Engineering in the School of Engineering of Columbia University. New York: John Wiley & Sons. London: Chapman & Hall. Ltd. Cloth; 6 x 9¼ ins.; pp. 725; 512 figures in the text. $5.

THE STEAM ENGINE AND GAS AND OIL ENGINES.—By J Perry, D. Sc., F. R. S., Professor of Mechanics and Mathematics in the Royal College of Science, Past President Institution Electrical Engineers. New York: The Macmillan Co.. Cloth: 6 x 9 ins.; pp. 325 text figures. $3.25 net.

STEAM BOILERS, THEIR THEORY AND DESIGN.—By H. de B. Parsons, M. Am. Soc. M. E., M. Am. Soc. C. E., etc., Consulting Engineer, and Professor of Steam Engineering, Rensselaer Polytechnic Institute. New York, London and Bombay: Longmans, Green & Co. Cloth: 6 x 9 ins.; pp. 375; many tables and 155 figures in the text. $4 net.

PUMPING MACHINERY.—A Practical Hand-Book Relating to the Construction and Management of Steam and Power Pumping Machines. By William M. Barr, M. Am. Soc. M. E. Philadelphia: J. P. Lippincott Co. Cloth; 6 x 9¼ ins.; pp. 447; 264 illustrations. $5.

CHIMNEY DESIGN AND THEORY.—A Book for Engineers and Architects. By William Wallace Christie, M. Am. Soc. M. E. Second Edition, Revised and Enlarged. New York: D. Van Nostrand Co. Cloth: 6 x 9 ins.: pp. 192: 53 illustrations. $3.

CIVIL ENGINEER'S POCKET-BOOK.—By John C. Trautwine, C. E. Revised by John C. Trautwine, Jr., and John C. Trautwine, 3d, Civil Engineers. New York: John Wiley & Sons. Leather; 4½ x 6¾ ins.: pp. xxxii + 1,079; many tables and illustrations. $5.

THE MECHANICAL ENGINEER'S POCKET-BOOK.—A Reference-Book of Rules, Tables, Data, Formulæ, for the Use of Engineers, Mechanics and Students. By William Kent, A. M., M. E., M. Am. Soc. M. E., M. Am. Inst. M. E., Dean and Professor of Mechanical Engineering in the L. C. Smith College of Applied Science, Syracuse University. Seventh Edition, Revised and Enlarged. New York: John Wiley & Sons. London: Chapman & Hall, Ltd. Morocco; 4¼ x 6¾ ins.; pp. xxxii + 1,129; many tables and illustrations. $5.

TREATISE ON HYDRAULICS.—By Mansfield Merriman, Professor of Civil Engineering in Lehigh University. Eighth Edition, Rewritten and Enlarged. New York: John Wiley & Sons. London: Chapman & Hall, Ltd. Cloth; 6 x 9 ns.; pp. 593; 55 tables, and 199 figures in the text. $5.

THE ELEMENTS OF WATER SUPPLY ENGINEERING.—By E. Sherman Gould. (See No. 4 on list.)

TABLES SHOWING LOSS OF HEAD DUE TOO FRICTION OF WATER IN PIPES.—By E. B. Weston, M. Am. Soc. C. E., M. Inst. C. E. New York: D Van Nostrand Co. Flexible Leather; 4 x 6 ins.; pp. 171. $1.50.

THE GRAPHICAL SOLUTION OF HYDRAULIC PROBLEMS.—Treating of the Flow of Water through Pipes, in Channels and Sewers, over Weirs, etc. By Freeman C. Coffin, M. Am. Soc. C. E. Second Edition, Revised and Enlarged. New York: John Wiley & Sons. London: Chapman & Hall, Ltd. Leather; 4¾ x 7½ ins.; pp. 79; 13 tables and 39 diagrams. $2.50.

HYDRAULIC DIAGRAMS FOR THE DISCHARGE OF CONDUITS AND CANALS.—Based upon the Formula of Ganguillet and Kutter. By Charles H. Swan, M. Am. Soc. C. E., and Theodore Horton, Jun. Am. Soc. C. E. With a Description of the Diagrams and their Use by Theodore Horton. New York: The Engineering News Publishing Co. Cloth; 6 x 9¼ ins.; pp. 43. $1.

THE MANUAL OF AMERICAN WATER-WORKS, 1897.—Compiled from Special Returns. Containing the History and Descriptions of the Source and Mode of Supply, Pumps, Reservoirs, Stand-Pipes, Distribution Systems, Pressures, Consumption, Revenue and Expenses, Cost, Debt and Sinking Fund, etc., etc., of the Water-Works of the United States and Canada. With Summaries for Each State and Group of States, and Water Rates Charged in over 1,250 Cities and Towns. Edited by M. N. Baker, Ph. B., Associate Editor of Engineering News. New York: The Engineering News Publishing Co. Cloth; 6 x 9¼ ins.; pp. 611 + lxiv. $3.

THE MUNICIPAL YEAR BOOK, 1902.—Giving the Population, Assessed Valuation, Principal Officials, and Ownership of Public Utilities; also information regarding the Water Supply, Sewerage, Street Cleaning, Street Sprinkling, Garbage, Fire and Underground Electric Service in all Incorporated Places in the United States, and in all New England Towns of 3,000 Population and Upwards by the Census of 1900. With Summaries and Editorial Discussion. Edited by M. N. Baker, Ph. B., C. E., Associate Editor of Engineering News. Author of "Sewage Purification in America," etc. New York: The Engineering News Publishing Co. Cloth; 6 x 9¼ ins.; pp. liv + 310. $3.

THE THEORY AND PRACTICE OF SURVEYING.—Designed for the Use of Surveyors and Engineers Generally, but Especially

for the Use of Students in Engineering. By J. B. Johnson, C. E., M. Inst. C. E., M. Am. Soc. C. E., late Dean of the College of Mechanics and Engineering of the University of Wisconsin. Sixteenth Edition, Revised and Enlarged. New York: John Wiley & Sons. Cloth; about 900 pages; illustrated. $4.

LETTERING FOR DRAFTSMEN, ENGINEERS AND STUDENTS.—A Practical System of Freehand Lettering for Working Drawings. Eighth Edition, Revised and Enlarged. By Charles W. Reinhardt, Chief Draftsman, Engineering News. New York: D. Van Nostrand Co. Boards; 11 x 8 ins.; pp. 34; 12 plates, and over 50 illustrations in the text. $1.

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SANITARY ENGINEERING OF BUILDINGS.—By William Paul Gerhard, C. E., M. Am. Public Health Asociation, Cor. M. Am. Inst. Architects, etc. Volume I. New York: William T. Comstock. Cloth; 7 x 10¼ ins.; pp. 454; six plates and 103 text illustrations. $5.

CARE OF THE HOUSE.—A Volume of Suggestions to Householders, Housekeepers, Landlords, Tenants, Trustees and Others for the Economical and Efficient Care of Dwelling Houses. By T. M. Clark. New York: The Macmillan Co. Cloth; 5 x 7½ ins.; pp. 284. $1.50 net.

THE MATERIALS OF CONSTRUCTION.—A Treatise for Engineers on the Strength of Engineering Materials. By J. B. Johnson, C. E., late Dean of the College of Mechanics and Engineering of the University of Wisconsin. Third Edition, Revised and Enlarged. New York: John Wiley & Sons. Cloth; pp. xv + 795; 11 plates and 650 illustrations. $6.

A TREATISE ON MASONRY CONSTRUCTION.—Containing Materials and Methods of Testing, Strength, etc.; Combinations of Materials—Composition, etc.; Foundations—Testing the Bearing Power of Soils, etc.; Masonry Structure—Stability Against Sliding, Overturning, Crushing, etc., etc. By Ira O. Baker, Professor of Civil Engineering, University of Illinois. Ninth Edition, Extensively Revised. New York: John Wiley & Sons. Cloth; pp. about 600; 160 figures and six folding plates. $5.

A TREATISE ON CONCRETE, PLAIN AND REINFORCED.—Materials, Construction and Design of Concrete and Reinforced Concrete. With Chapters by R. Feret, William B. Fuller and Spencer B. Newberry. By Frederick W. Taylor, M. E., and Sanford E. Thompson, S. B., Assoc. M. Am. Soc. C. E. New York: John Wiley & Sons. London: Chapman & Hall, Ltd. Cloth: 6 x 9 ins.; pp. 585; 176 figures in the text. $5.

REINFORCED CONCRETE.—Part I., Methods of Calculation. By A. W. Buel. Part II., Representative Structures. Part III., Methods of Construction. By C. S. Hill. New York: The Engineering News Publishing Co. Cloth; 6 x 9 ins.; pp. 434; tables, and 311 figures, some on folding plates. $5.

REINFORCED CONCRETE.—By Charles F. Marsh, Assoc. M. Inst. C. E., Assoc. M. Inst. M. E. New York: D. Van Nostrand Co. Cloth; 8 x 11 ins.; pp. 545; tables, and 512 illustrations, mostly in the text. $7 net.

CEMENTS, MORTARS AND CONCRETES.—Their Physical Properties. By Myron S. Falk, Ph. D., Instructor in Civil Engineering in Columbia University. New York: M. C. Clark. Cloth; 6 x 9 ins.; pp. 176; tables, plates and figures in the text. $2.50.

EARTHWORK AND ITS COST.—By Halbert Powers Gillette, M. Am. Inst. M. E., Associate Editor Engineering News. New York: The Engineering News Publishing Co. Cloth; 5 x 8 ins.; pp. 244; tables, folding plates and illustrations in the text. $2.

ROCK EXCAVATION.—Methods and Cost. By Halbert Powers Gillette, M. Am. Soc. C. E., M. Am. Inst. M. E., Late Assistant New York State Engineer. New York: M. C. Clark. Cloth; 5½ x 8 ins.; pp. 370; 56 figures in the text. $3.

THE INDUSTRIAL AND ARTISTIC TECHNOLOGY OF PAINT AND VARNISH.—By Alvah Horton Sabin, M. S., M. Am. Soc. M. E. New York: John Wiley & Sons. London: Chapman & Hall, Ltd. Cloth; 6 x 9 ins.; pp. 372; tables, half-tone plates, and illustrations in the text. $3.

A TREATISE ON ROADS AND PAVEMENTS.—By Ira Osborn Baker, C. E., M. Am. Soc. C. E., Professor of Civil Engineering, University of Illinois. New York: John Wiley & Sons. Cloth; 6 x 9 ins.; pp. 655; 68 tables and 171 illustrations. $5.

TUNNELING.—A Practical Treatise. By Charles Prelini, C. E. With Additions by Charles S. Hill, C. E., Associate Editor "Engineering News." Second Edition, Revised. New York: D. Van Nostrand Co. Cloth; 6 x 9¼ ins.; pp. 311; 149 figures in the text. $3.

ORDINARY FOUNDATIONS.—Including the Cofferdam Process for Piers. With Numerous Practical Examples from Actual Work. By Charles Evan Fowler, M. Am. Soc. C. E. Second Edition, Revised and Enlarged. New York: John Wiley & Sons. London: Chapman & Hall, Ltd. Cloth; 6 x 9 ins.; pp. xxvi + 314; 49 figures and 15 tables in the text. $3.50.

ENGINEERING CONTRACTS AND SPECIFICATIONS.—Including a Brief Synopsis of the Law of Contracts and Illustrative Examples of the General and Technical Clauses of Various Kinds of Engineering Specifications. Designed for the Use of Students, Engineers and Contractors. By J. B. Johnson, (late) Dean of the College of Mechanics and Engineering, University of Wisconsin. Third Edition, Revised. New York: The Engineering News Publishing Co. Cloth; 6 x 9 ins.; pp. 566. $3.

THE LAW OF OPERATIONS PRELIMINARY TO CONSTRUCTION IN ENGINEERING AND ARCHITECTURE.—Rights in Real Property, Boundaries, Easements and Franchises. For Engineers, Architects, Contractors, Builders, Public Officers, and Attorneys at Law. By John Cassan Wait, M. C. E., LL.B., M. Am. Soc. C. E. New York: John Wiley & Sons. London: Chapman & Hall, Ltd. Cloth; 6 x 9 ins.; pp. lxiii + 638. $5; $5.50.

ENGINEERING AND ARCHITECTURAL JURISPRUDENCE.—A Presentation of the Law of Construction for Engineers, Architects, Contractors, Builders, Public Officers and Attorneys at Law. By John Cassan Wait, M. C. E., LL.B., M. Am. Soc. C. E. New York: John Wiley & Sons. London: Chapman & Hall, Ltd. Cloth; 6 x 9 ins.; pp. lxxx + 905. $6; $6.50.

ELEMENTS OF GEOLOGY.—A Text-Book for Colleges and the General Reader. By J. Le Conte. Revised and Partly Rewritten by Herman LeRoy Fairchild, Professor of Geology in the Uni-

versity of Rochester. New York: D. Appleton & Co. Cloth; 6 x 9 ins.; pp. 667; one plate and 1,002 text illustrations. $4.

ELEMENTARY METEOROLOGY.—By Frank Waldo. New York: American Book Co. Cloth; 5 x 7 ins.; pp. 373; 121 plates and text figures. $1.50.

METEOROLOGY.—By T. Russell. New York: The Macmillan Co. Cloth; 6 x 9 ins.; pp. xxiii+277; 22 plates and 29 text figures. $4.

ELEMENTS OF PHYSICS.—By Henry Crew. New York: The Macmillan Co. Cloth; 5 x 8 ins.; pp. xvi+353; 266 text figures. $1.10 net.

UNIVERSITY PHYSICS.—By H. S. Carhart. (2 parts; $1.50 each.) Boston: Allyn & Bacon.

PRACTICAL FORESTRY.—For Beginners in Forestry, Agricultural Students, Woodland Owners and Others Desiring a General Knowledge of the Nature of the Art. By John Gifford, Assistant Professor of Forestry (in the late) New York State College of Forestry, Cornell University. New York: D. Appleton & Co. Cloth; 5 x 8 ins.; pp. 284; plates and text illustrations. $1.20 net.

PRINCIPLES OF AMERICAN FORESTRY.—By Samuel B. Green, Professor of Horticulture and Forestry, University of Minnesota. New York: John Wiley & Sons. Cloth; 5 x 8 ins.; pp. 334; 72 illustrations, including plates. $1.50.

OUR NATIVE TREES AND HOW TO IDENTIFY THEM.—A Popular Study of Their Habits and Their Peculiarities. By Harriet L. Keeler. New York: Charles Scribner's Sons. Cloth; 5 x 8 ins.; pp. 533; 178 illustrations from photographs and 162 from drawings. $2 net.

THE PRINCIPAL SPECIES OF WOOD.—Their Characteristic Properties. By Charles Henry Snow, M. Am. Soc. C. E., Dean of the School of Applied Science, New York University. New York: John Wiley & Sons. Cloth; 7 x 10 ins.; pp. 203; 39 plates and numerous figures in the text. $3.50.

LANDSCAPE GARDENING.—Notes and Suggestions on Lawns and Lawn Planting, Laying Out and Arrangement of Country Places, Large and Small Places, Cemetery Plots and Railway Station Lawns, Deciduous and Evergreen Trees and Shrubs, the Hardy Border, Bedding Plants, Rockwork, etc. By Samuel Parsons, Jr., Superintendent of Parks, New York City. New York: G. P. Putnam's Sons. Cloth; 7½ x 10 ins.; pp. 329; 176 illustrations in the text. $3.50 net.

HOW TO PLAN THE HOME GROUNDS.—By Samuel Parsons, Jr. New York: Doubleday, Page & Co. Cloth; 5 x 8 ins.; pp. 249; 56 illustrations. $1 net.

IMPROVEMENT OF TOWNS AND CITIES.—By Charles Mulford Robinson. New York: G. P. Putnam's Sons. Cloth; 5 x 7 ins.; pp. 391. $1.25 net.

MODERN CIVIC ART.—Or the City Made Beautiful. By Charles Mulford Robinson. New York: G. P. Putnam's Sons. Cloth; 6 x 9 ins.; pp. 381. $2.50 net; by mail, $2.70.

HOW TO JUDGE ARCHITECTURE.—A Popular Guide to the Appreciation of Buildings. By Russell Sturgis, F. A. I. A. New York: The Baker & Taylor Co. Cloth; 6½ x 9¾ ins.; pp. 221; 55 plates. $1.50 net.

MUNICIPAL PUBLIC WORKS.—Their Inception, Construction and Management. By S. P. Whinery, C. E. New York: The Macmillan Co. Cloth; 6 x 8 ins.; pp. 241. $1.50 net; by mail, $1.63.

THE AMERICAN CITY.—A Problem in Democracy. By Delos F. Wilcox, Ph. D. New York: The Macmillan Co. Half Leather; 5 x 8 ins.; pp. 423. $1.25.

MUNICIPAL GOVERNMENT IN GREAT BRITAIN.—By Albert Shaw. New York: The Macmillan Company. Cloth; 6 x 8¼ ins.; pp. 348. $2 net.

MUNICIPAL GOVERNMENT IN CONTINENTAL EUROPE.—By Albert Shaw. New York: The Macmillan Co. Cloth; 6 x 8½ ins.; pp. 505.

MUNICIPAL MONOPOLIES.—A Collection of Papers by American Economists and Specialists. Edited by Edward W. Bemis, Ph. D., Professor of Economic Science in the Kansas State Agricultural College. New York and Boston: Thomas Y. Crowell & Co. Cloth; 5 x 8 ins.; pp. 691. $2.

MUNICIPAL TRADE.—The Advantages and Disadvantages Resulting from the Substitution of Representative Bodies for Private Proprietors in the Management of Industrial Undertakings. By Major Leonard Darwin. New York: E. P. Dutton & Co. Cloth; 6 x 9 ins.; pp. 464. $3.50 net.

DISCUSSION.

Mr. Charles: I would like to mention a book which has been omitted, but I do not mention the omission as criticism, because no matter how large you make such a list something will necessarily be left out. The little book I have in mind I consider one of the most valuable I have, although its author does not appear to be conspicuously known. I think the title is "Practical Hydraulics," by Randall, San Francisco. It is a small book costing only seventy-five cents or a dollar, yet containing much valuable information in the way of tables, etc., perhaps more than any other two works that I have yet seen.

Secretary Diven: I was a little surprised at Mr. Baker's leaving out the most important book for the water works library, viz.: Proceedings of the American Water Works Association! There is also a book of which I cannot recall the exact title or the publisher's name, by Allen Ripley Foote, I think, "Laws Covering Quasi Municipal Corporations." I found some very good things in that, although the book is old now.

Mr. Gwinn: I feel that this association is indebted to Mr. Baker for his very valuable résumé. Personally I feel under obligations to him for having called our attention to so many good books.

I was glad to find that I had some of the books which he has enumerated, and especially Fanning, which was the first water works book I had anything to do with. I enjoyed it very much. One book that I have gotten a great deal of information out of is Mr. Goodell's book on "Water Works in Small Cities and Towns," referred to by Mr. Baker. I do not think that any member of this association could do better than to procure a copy of that book. You will be surprised at the amount of information you will find between its covers. It touches upon almost every subject that comes up in water works practice, especially in the engineering department.

Another book that I have gotten a good deal out of is Rider's "Little Engineer," costing three dollars and embracing a great deal of valuable information and tables. Mr. Baker's book, "Manual of American Water Works," is a compilation of statistics of water works plants, and I have occasion to consult it frequently I wish Mr. Baker would prepare a new edition and include in it, in tabulated form, the bids on water works construction and machinery that have been published in recent years.

I was going to speak also of the proceedings of the American Water Works Association and the New England Water Works Association. The index that the latter association has recently gotten out is a very valuable work, and I should think it would be a good thing for our secretary, when he is taking a vacation, to get up a similar index of the proceedings of the American Water Works Association.

Secretary Diven: That will be published this year, going back to the beginning.

Mr. Gwinn: The recent papers at least might be indexed.

Secretary Diven: I was working on that index when I got an idea from Mr. Baker which got me into very serious trouble, for I then started on an analytical index to all the papers and proceedings on the card index plan. I have just gotten through with the first five years and am pretty well along on the third thousand of those cards. I think there will be anywhere from 10,000 to 15,000 cards by the time I

get through. How many of them will be eliminated on the final sorting over I cannot say. I hope a great many.

Mr. Rosamond: One book not mentioned in Mr. Baker's list I would like to ask about, that is, Freeman's "Tables on Fire Streams." I have tried to get it and have been informed that it is out of print. I used a copy for a short time that had been through a fire. I found the work a very valuable one to water works men. I also have Goodell's, which contains some of these tables, but not the tables complete.

Secretary Diven: The secretary of the American Society of Civil Engineeers informed me some time ago that they were intending to reprint Freeman's paper. I have never heard, however, that it has yet been done.

SOME ADDITIONAL NOTES ON PIPE COATING.

By F. W. Cappelen, M. Am. Soc. C. E.

Since the construction of the Minneapolis 50-inch steel pipe lines for the Minneapolis water-works, several separate reports on the conditions of said lines have been made both to this society as well as to individuals. As, however, requests for information continue to arrive, the writer thinks it might be of general interest to present a condensed report covering the subject from its inception up to date.

During the winter 1896-97, it became the writer's duty to prepare specifications for about sixty-five miles of fifty-inch riveted steel pipe. The troublesome feature was the coating. After several experiments and a great many tests having been made (see paper on Tests of coating for steel water pipe by the writer read before the Am. W. W. Association at Denver, 1897). A coating called mineral rubber asphalt from Utah was selected.

The pipes were furnished and laid by the T. A. Gillespie Co., of Pittsburg and New York. The pipes were made in twenty-eight (28) feet sections. They were thoroughly cleaned, dried and heated to about 300° Fahrenheit and then immersed in vertical tanks containing the coating heated to 300°. The pipes arrived in Minneapolis in excellent condition and the coating suffered very little in railroad transportation, and the hauling of an average of three miles on wagons to the ditch and in final handling and riveting. Abraised parts and field riveted joints were painted in the field.

In 1898 your committee on pipe coating, Mr. Sherred and the writer reported in favor of the mineral rubber coating (see proceeding A. W. W. Ass'n, 1898).

Some of the original test pipes coated in the early part of 1897 were exposed to the air for one year, then they were immersed in running city water for one year and thereafter they laid one year in one of the big sewers of Minneapolis. The pipes were examined after each treatment and in every case the mineral rubber showed up the best. The different coatings referred to were:

No. 1. Mineral rubber asphalt from Utah.

No. 2. Trinidad asphalt mixed with dead oil as used for the 42-inch steel pipe line in Duluth, Minn.

50-INCH STEEL MAIN, MINNEAPOLIS, MINN.

No. 3. California asphalt.

No. 4. California asphalt, mixed with 40 per cent. of maltha.

No. 5. Pipe dip, practically the so-called Angus Smith coating.

So much for tests, now a few words from actual personal experience.

In May, 1900, the writer personally inspected the inside of the 50-inch lines in Minneapolis and found the coating just as good as new. Near one of the joints he found a lump of coating which was removed. The material was exactly as the original one, glossy and elastic.

In May, 1903, the writer examined the outside of the pipe line in several places, choosing such points where the soil was of a different character such as sand, clay and in one place swamp land. In all cases the coating was excellent. In 1904 connections with the steel lines were made with the new pumping station. The story is the same; the coating was as good as new, both inside and outside. A few days ago the writer again examined the inside; the result was the same. In one place the writer found a lump of coating material. The material was elastic enough so that a pen-knife could be inserted and stick, although the ice cold water was not yet all drained out of the pipe. The lump of coating was removed and is herewith submitted. The writer considers this sample very interesting, when it is considered that the pipe lines have been in use toward eight years. The metal under the coating was perfect.

The writer found upon the last investigation by cleaning of a field joint that the coating of the top of a couple of rivets came off. This coating was the paint used in the field and the writer would on a new job in the field use the hot mineral rubber coating, even if it should be necessary to heat the pipes, by applying waste dipped in kerosene and ignited. As there are at the present writing several feet of frost in the ground it was impossible to again examine the pipes from the outside.

Upon the writer's advice the City of Seattle, Wash., in 1899 used the mineral rubber coating for seven miles of 42-inch steel pipe. Mr. R. H. Thomson, city engineer of Seattle, writes under date of April 4, 1905, that the coating is still bright and firm at any place where it has been examined.

The analysis of the coating as it is to-day on the inside of the pipe shows:

Petrolene	68.1 %
Asphaltene	27.26%
Total bitumen	95.36%
Organic matter	3.42%
Ash	1.22%
Total	100.00%

RECOMMENDATION.

The author would recommend coating to be of a consistency as nearly as possible as the one used in Minneapolis. He would also use the same coating applied hot for field work, and insist on absolute cleaning of pipes by the use of sandblast before dipping.

A FEW PRACTICAL HINTS.

S. A. Charles, Lexington, Ky.

Having been requested by the secretary to read a short paper, with the added request that it should be practical, I have selected a few topics, founded principally on my own experience. I do not claim that experience is exhaustive, but it may be suggestive to others, they may possible benefit by it, and if there is any discussion I in turn may learn from their experience.

I begin with the selection and purchase of coal. This is a large item of expense with most water works companies, and there is a vast difference in the values of coals. The highest priced may be the cheapest to use, on account of its greater efficiency. How shall we determine which of a number of samples offered by competing dealers at various prices is the best to use? Laboratory tests and analyses are of but little value, as they are on too small a scale, and for the still better reason that the supply furnished seldom or never equals the sample furnished and tested.

Our own plan has been in May or June of each year to invite bids for a year's supply under the following condition. At least a car load of the coal which it is proposed to furnish must be delivered to us in advance, to be tested under our boilers. Bidders are especially requested not to send anything better than they can duplicate and furnish regularly. The coal thus sent to be tested is not furnished gratuitously, but is paid for whether the subsequent bid is accepted or not.

These sample car loads are tested under our boilers under the usual conditions existing in our plant. A careful record is kept every day, and has been for years, of the number of pounds of coal burned each day, the number of gallons of water pumped, with the pressure or head, and the number of gallons of water evaporated in the boilers. This last is arrived at by meter measurement. From these data we easily determined the evaporating powers of the coals tested, which with us (using soft coal) averages about eight and three-quarter pounds of water to each pound of

coal burned. Testing by evaporation of course eliminates all losses or errors arising from the friction or imperfection of the machinery, and give the relative amounts of effective carbon in the coals tested. After having thus tested the evaporating powers of the samples submitted, a comparison is made, taking now into account the cost of each sample, and the contract is awarded to the best bidder. In making the contract we stipulate that the coal furnished shall equal the sample tested in evaporating power and agree to pay a pro rata increase if better results are obtained, and to make a pro rata reduction for any failure to equal the evaporation standard. At the outset, some years ago, it was difficult to obtain bids under these conditions, but we have adhered strictly to this method and now have no difficulty in making such contracts. Any company contracting in this way will, I think, be agreeably surprised at the results.

My next hint is on the selection and purchase of meters. I believe that any of the meters now on the market are a vast improvement over the schedule system; still, among them there may be points of superiority, and, without recommending any meter whatever, I will indicate some of the points we consider in our own selection. First, a meter should be tested under the same conditions, as nearly as possible, as will exist when using it. It may be desirable that a meter should be perfectly accurate at all pressures and with all sized streams, but, as this is hardly possible, we are satisfied if it registers within one per cent. of the correct amount (and that in the customer's favor) at our regular pressure and with openings within the reasonable capacity of the meter. We test every meter before setting it, and, if necessary, change the gearing in the clockwork to make the meter register as nearly as possible only 99 per cent. of the water passing through it. We prefer to have our meters record slightly in favor of our customers, so that, when a customer is dissatisfied, we can demonstrate that the meter is in his favor instead of against him and that any losses or apparently excessive bills must be due to actual use, waste or leaks. The difference of one per cent is but

trifling, but it goes a long way towards satisfying, or at least silencing, a dissatisfied customer, but beware of having your meter even one-half of one per cent. against your customer when you test it, especially if you test in his presence.

We think the cost of a meter is the last thing to be considered; that, while economy is always desirable, yet there is such a thing as mistaken economy, and this is especially true of meters; some might be dear at any cost, even as a gift, if their use involves a loss of revenue to the company. It is evident that a meter which is so delicate as to be stopped by the most trifling obstruction, or fails to register minute streams or leaks, is not a profitable meter for a company to use, and the loss would be in proportion to the price at which water is furnished.

I believe these small leaks and losses amount to much more in the aggregate than is usually suspected. A stream, for instance, through an opening not larger than one-thirty-second of an inch in diameter would make with us, if not recorded by the meter, a loss of $1.27 per month, or $15.24 per annum. Such a meter would be dear even as a gift. Two or three dollars saved in cost is dearly saved if it involves a loss of four or five times that amount in annual revenue.

A good way of testing meters on small streams is with small discs with bores of known size running from one-thirty-second of an inch to one-quarter inch, or, as I have recently seen by a new device which I presume will be on exhibition here, in which device turning a small lever or handle to the figure on a circle will open an aperture of the size indicated by the figure. A comparison of the *relative* recording powers of two or more meters may be easily and quickly made by simply coupling them together in line, tandem fashion, and running a stream through them simultaneously, throttling the outlet more and more until one or all stop recording. In this experiment it is well to reverse the positions of the meters once or twice and to see that there are no obstructions to the flow.

As to systems of locating meters and keeping meter ac-

counts, I have described our methods at former meetings and do not think it necessary to repeat, except to say that one man can still read 500 meters a day and with the aid of a helper to lift meter covers can read 600 a day (ten hours to the day) and is doing so regularly, at least Mr. Funk, my successor and present superintendent, states that they are, and authorizes me to invite any doubting Thomas to make him a visit and he will take pleasure in demonstrating the fact, and that in a day of not exceeding ten hours. Our bookkeeper also will demonstrate his ability, with the aid of prepared tables and the "Addressograph," to make out 1,200 to 1,500 bills in a day or post from 1,500 to 2,000 credits from the special cash book to the individual accounts in the meter ledger. I hope the convention will pardon me this digression in view of the incredulity manifested at the meeting when I stated these facts.

My next hint is in regard to bookkeeping. There seems to have been an effort to devise a system to be adopted by all companies regardless of their individual necessities, the principal object of so doing being apparently to secure a uniformity of reports and statistics for easier comparison, and we find sets of books for sale for this purpose. This seems to me to be placing the cart before the horse, that the first and the principal thing to be done is to agree on what reports are essential for the information of investors in water works plants, leaving it to the ingenuity of the individual companies to keep their books in the simplest and easiest way possible, so that they accomplish the result. Most of the books and forms I have seen in use or recommended for the use of water works companies might, I think, be simplified and the labor of keeping lessened with an improvement in clearness. Many municipalities seem to require an unnecessary amount of detail in their reports and a lot of information which is of but little, if any, value. I think the general public and even water works men care little, if anything, how many picks or crowbars or pounds of nails are in stock and that the space given to such trifles is wasted.

If the bookkeeper is intelligent, takes an interest and pride in his work and is not there for pay only, he can generally materially lighten the labor of bookkeeping, lessen the number of assistants required, and still do the work better. A fair amount of previous bookkeeping experience, a moderate amount of inventive ability, some independence of obsolete precedents and unnecessary repetitions will give every plant a system adapted to its own wants.

There is, however, one book which I think might be kept with advantage by all superintendents. That is a scrapbook in which to paste or file all clippings from papers or periodicals or notes of any matter likely to prove useful in the business. A small note or pocket book which can be carried on the person may easily contain the cream of twenty books or manuals. I heartily agree with Mr. Baker about the necessity of a water works library for a live plant. We have had one for years and add to it from time to time as new works of merit appear. It includes many of those recommended by Mr. Baker.

Last, but not least, superintendents and managers will find the efficiency of their working force increased by cultivating a friendly or even cordial manner with employes. A friendly "good morning" or "good night," a manifestation of interest in them and especially a visit or more in case of sickness, an occasional consultation with them about the work to be done and the best way of doing it, goes a long way to make an efficient corps and allay all discontent. The highest compliment I ever received, in my judgment, was the statement from one of our employes that "there wasn't a man on the force that wouldn't die for me." This, of course, was exaggerated, but it illustrates the feeling that will exist where all pull together. We have made it a practice to consult our men and hold what we jocularly call "our councils of war" and have frequently received valuable suggestions, sometimes where least expected.

With these remarks, thanking you for your attention, I close.

DISCUSSION.

Mr. Henry L. Lyon (by letter): Mr. Charles in his paper on "Experience" explains his way of buying coal. It was a subject I was very much interested in, but I did not then reply, because the convention was about to adjourn for lunch, and I did not have my specifications with me.

It has been a source of considerable annoyance to me for a long while that I must advertise for coal, and have the common council insist upon taking the lowest bid. I have had statements given of the mines from which the coal was to come, and have experimented with sample cars of coal, but we use about fifty thousand tons a year, and large quantities would be run in and unloaded and mixed with other coals that were nowhere near the sample and almost worthless. I am certain that at times last winter we burned twenty-five tons of coal a day more than would have been necessary if we had received what we had contracted for. Our contract price was $2.08 per ton, and this extra coal had also to be unloaded and handled. It also required the use of more boilers, and even then it was impossible to keep up the steam to the required pressure. I decided I must do something, and prepared the following specifications:

There will be required fifty thousand tons (more or less) of bituminous coal (run of mine) to be delivered on the switches at the pumping station, Bureau of Water, Buffalo, N. Y., and will be required from April 1, 1905, to April 1, 1906.

The coal shall be delivered in hopper bottom cars. In case the openings are out of order, or covered with slabs or other obstructions, the Bureau of Water reserves the right to refuse the cars, or to charge extra expense of handling at its option and deduct such extra expense from any bills rendered.

The Bureau of Water reserves the right to weigh the coal on its own scales and pay according to its scale weights.

The coal shall be delivered at such time and in such quantities as the deputy water commissioner shall direct. It is expected, however, that the contractor will deliver a regu-

lar and uniform quantity daily as the needs of the Water Bureau require.

The Bureau of Water will unload the coal without unnecessary delay, but, in case, for any reason, more coal is delivered any day than the Bureau requires, the contractor shall be liable for any demurrage, and for any extra expense that may be incurred in handling the same.

The coal shall be a bituminous or semi-bituminous, free burning coal, clean, free from slate, stone or other impurities, and fresh mined.

All coal received at the pumping station will be carefully sampled and tested. A bomb calorimeter of approved design will be used for the purpose. All coal must contain at least 12,500 British thermal units, and payments will be made according to the heat value of the coal as tested. The price paid to be in equal proportion for any increase in British thermal units.

If the non-combustible in any car of coal exceeds ten per cent (10 per cent.) the price will be reduced in proportion to the extent of the excess over the said ten per cent.

The slack in run of mine coal must not exceed twenty per cent. (20 per cent.) of the weight of coal in such car.

If, in the opinion of the deputy water commissioner, any car of run of mine coal contains more than twenty per cent. (20 per cent.) of slack, the price paid for such coal will be reduced in proportion to the amount of slack in excess of the said twenty per cent.

The commissioner of public works reserves the right to reject any or all bids, or to accept any part of any bid.

The printed papers hereto attached, and headed "General Specifications" shall be considered a part of these specifications.

Specifications can be seen at the office of Henry L. Lyon, deputy water commissioner, Municipal Building, Buffalo, N. Y.

Proposals must be submitted to Francis G. Ward, commissioner of public works, Room 1, City and County Hall, Buffalo, N. Y., and must be presented not later than 11 a. m., March 22, 1905.

I advertised in March for coal under these specifications. The coal men objected and came in to ask what B. T. U. meant. They had never heard of such a thing, and had no idea what the heat value was. Some of them bid however, and I made a contract this year April 1, 1905, to April 1, 1906, at $1.95 per ton. I have made tests only about twice a week, that will be sufficient unless some strange coal comes in, or the tests differ materially. It takes only about half an hour for a test.

An average so far shows 14,287 B. T. U.'s, and we will pay $2.22 per ton for the excess of B. T. U.'s, from which we will deduct 5 per cent., or ten cents per ton for excess of slack over 20 per cent., and 10 per cent., or nineteen cents per ton for excess of non-combustible over 10 per cent., leaving the net price of the coal $1.93 per ton. We are also using nearly 20 per cent. less coal than last year. A test of some of last year's coal showed only 12,460 B. T. U.'s with 40 per cent. slack and 30 per cent. non-combustible. The contract price was $2.08 per ton, and we would have paid, if we had worked under these specifications, $2.07 per ton on account of the B. T. U.'s, from which we would have deducted 20 per cent., or twenty-two cents on account of excess of slack, and 20 per cent. more, or twenty-two cents on account of excess of non-combustible, leaving the net price of the coal $1.63, and it would have been dear at that.

Respectfully,

HENRY L. LYON,
Deputy Water Commissioner.

A NEW METHOD FOR MECHANICALLY OPERATING SCREENS.

J. Ralph Van Duyne,

Asst. Engr. Dept. of Water, Newark, N. J.

A new storage reservoir for Newark, N. J., with a capacity of 700,000,000 gallons will be placed in service in August of this year.

The reservoir is a mile long and an eighth of a mile wide, and together with a 3,000-foot tunnel, an 8-mile pipe line and connections with city mains, will cost in round numbers $2,000,000.

The Outlet Gate Chamber controlling the flow of water to the city is located in the reservoir basin 65 feet from shore and in a depth of 50 feet of water.

In this chamber are four wells each 8 feet long and 6 feet wide, through which the water passes before entering the distribution system.

In the two front wells are cast iron grooves in which the screens slide.

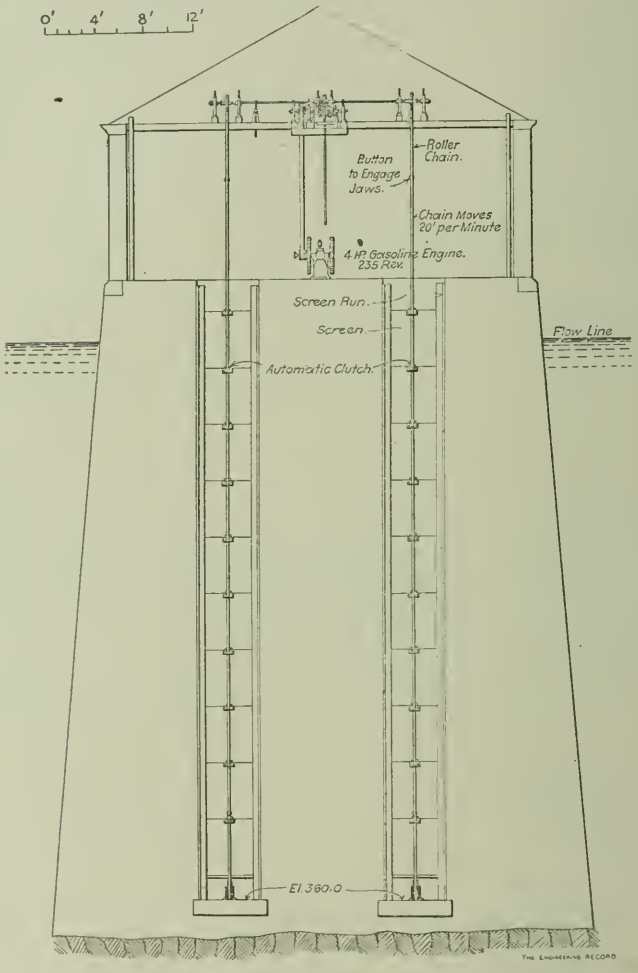
The frames for the screens instead of being made of wood, as is customary, are 2½-inch by 2½-inch by ⅜-inch steel tees bent to form a 4-foot 7-inch square. Onto this frame is riveted a sheet of number 18 hard copper punched with 5-16-inch holes, 7-16-inch on centers.

At the center top edge of each screen is attached a pair of sliding jaws which are forced upwards by a stiff spiral spring converging as they rise. As the screens are placed, one on top of the other, the jaws to each under screen are forced down and open by the weight of the screen above, so that when the screens are all in place all of the jaws are down except the ones on the top screen.

The power transmission to raise and lower these screens is very simple.

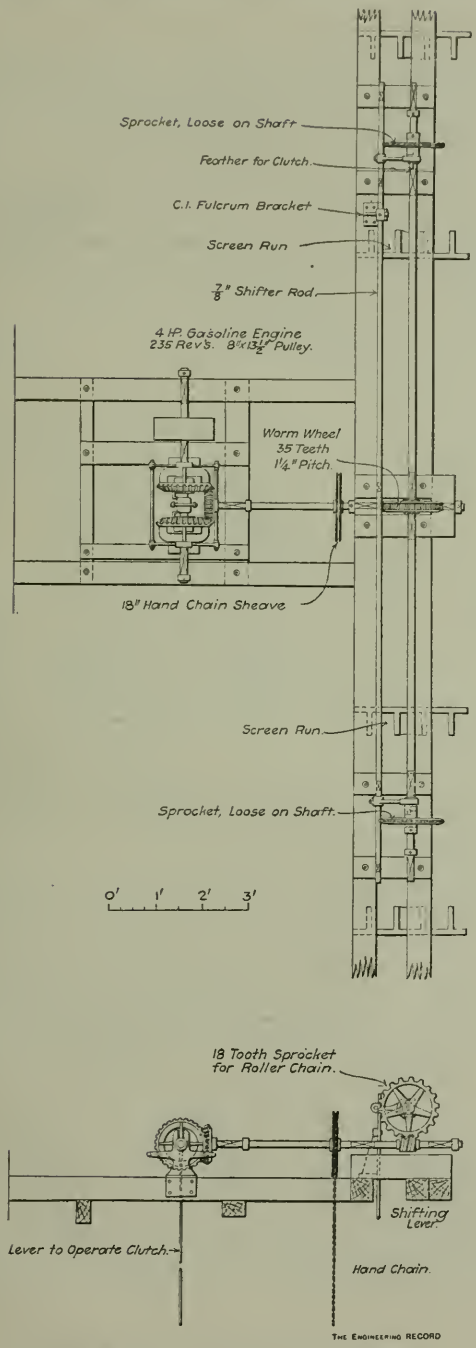
On a shaft 12 feet above the floor of the Gate Chamber are placed two sprocket wheels, one over each well in which the screens are located. Engaging these wheels is an endless sprocket chain extending 60 feet down to idlers at the bottom of each well. Two special links or buttons one inch greater

in width than the remaining links are inserted diametrically opposite to each other in each chain. These chains pass through the jaws attached to each screen and the jaws are so spaced that when pressed down both chain and button will pass



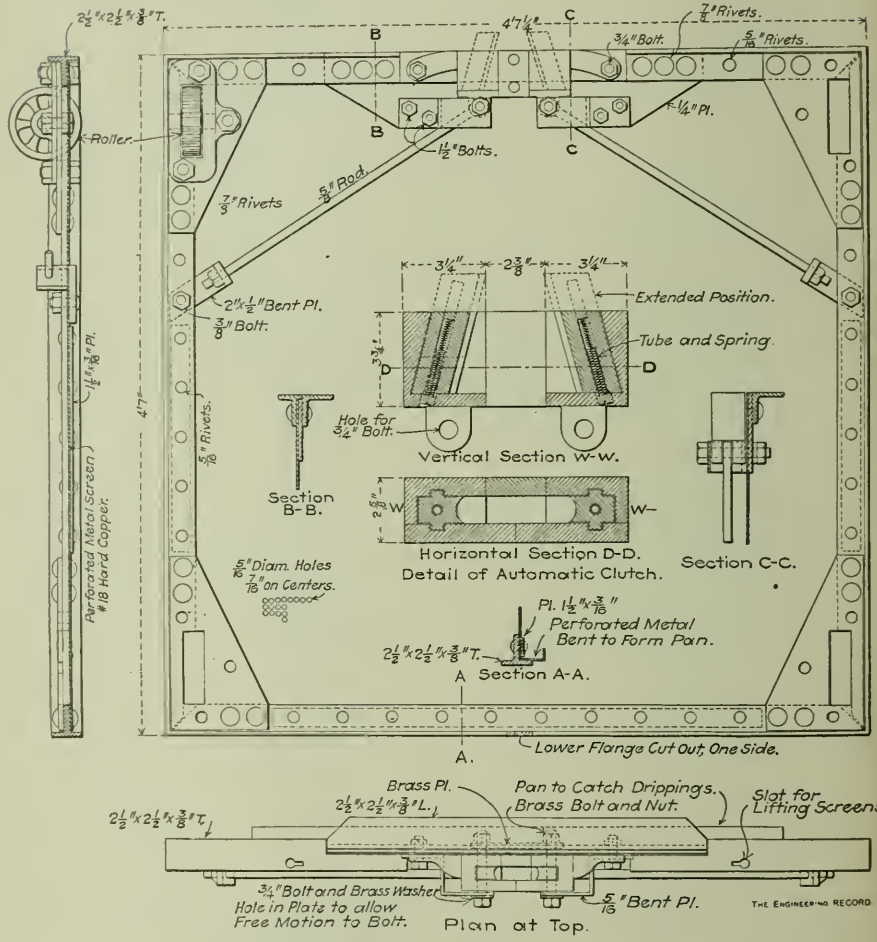
SKETCH SHOWING GENERAL ARRANGEMENT.

through, when the jaws are released, however, only the chain can pass through and hence as the button comes up it engages in the jaws of the top screen and raises this screen out of the well.



PLAN AND SIDE ELEVATION OF SHAFTING.

Cams which hold the jaws together are then swung back, the jaws are opened and the screen is released from the chain. It is then picked up by a differential chain block and carried on an overhead track to the center of the chamber where it is



DETAIL OF SCREEN AND AUTOMATIC CLUTCH DEVICE.

washed and then either returned to the well or stored in another part of the Gate House.

A 4 horse-power gasolene engine with a friction clutch attached to the pulley furnishes the power and a worm wheel

drive is used to transmit the power to the main shaft on which the sprocket wheels are placed. A shifting lever is used to throw the sprocket wheels into clutch with the main shaft and a double beveled gearing is used to reverse the direction of the shaft. The screens are raised out of the wells at a rate of 20 feet per minute.

So far the writer has not heard of any arrangement quite similar to the one described, and while it has not as yet been in actual operation under all conditions of service for which it is designed, the tests made up to the present time have been satisfactory.

The original design was worked out by Carleton E. Davis, my predecessor, and installed by me under the direction of Mr. Sherrerd, Chief Engineer.

DISCUSSION.

Mr. French: I would like to ask if the screens are arranged to work singly or double?

President Sherrerd: Clean screens are put down in the second groove as the others are raised. There is always a set left in. The chain goes over an idler of sufficient width so that the screens can be raised or lowered on either side of the pulley by reversing the motion. There is an idler that is placed under a plate at the bottom of the well. The plate has two holes where the chain runs through.

We have a paper from Mr. J. Waldo Smith, which was submitted at my request, and covers the method employed to hasten the construction of the Croton dam, which I think will be particularly interesting to water works men. I will ask the secretary to read it.

METHODS USED TO INCREASE THE RATE OF PROGRESS IN THE CONSTRUCTION OF THE NEW CROTON DAM.

J. Waldo Smith,

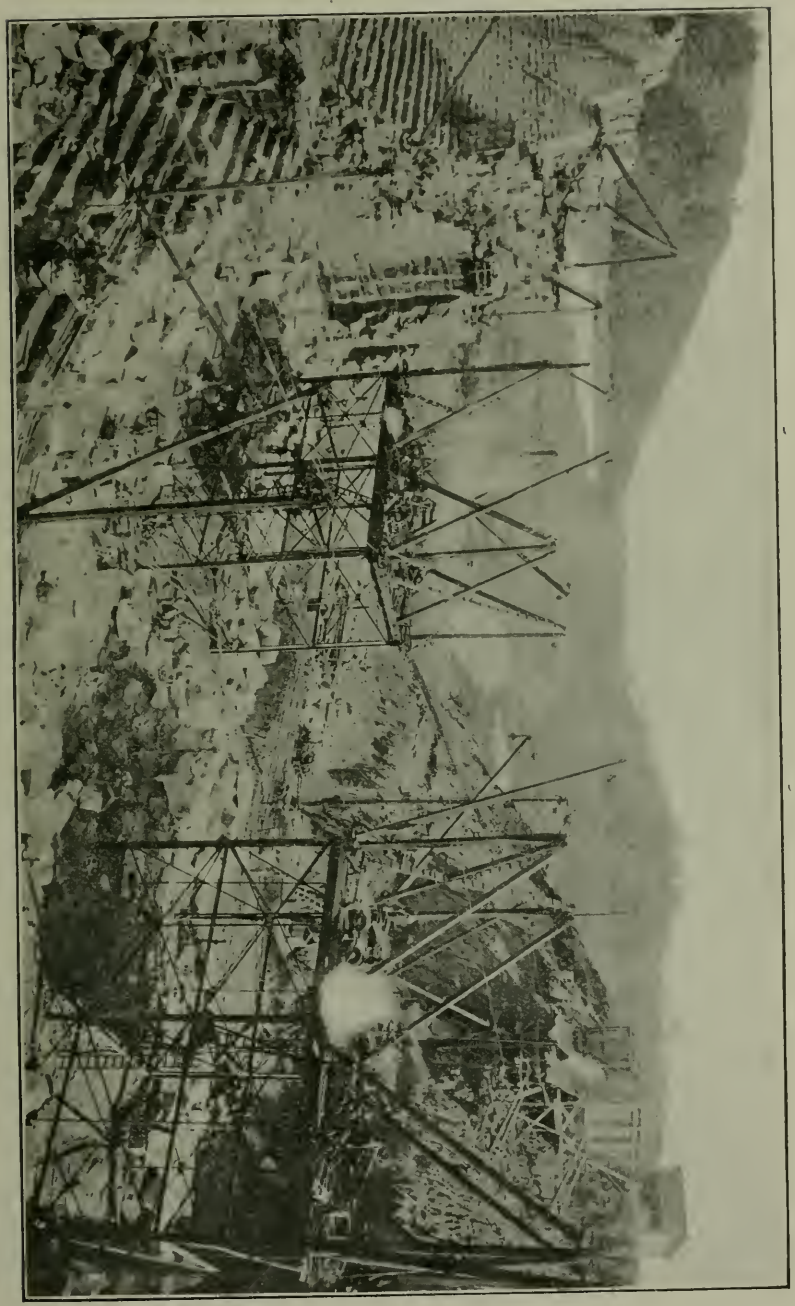
Chief Engr. Croton Aqueduct Commission, New York City.

At the opening of the working season of the year 1904 the condition of the water supply of the City of New York was such as to render imperative the completion of the New Croton Dam to such a height as to allow the storing of a considerable quantity of water. About 290 feet of the southerly end of the dam had been torn down, as was described in a paper presented a year ago to this association by Mr. William R. Hill, the former Chief Engineer.

Late in the season of 1903 the excavation on this southerly end had been completed, and in order that any water could be stored at the end of 1904 it was necessary to raise the masonry to a height of about 180 feet above the foundation. This so-called southerly extension of the main dam is about 290 feet long. It has been built in an excavation deep in the hillside, where it was rather difficult to deliver and handle materials rapidly. Under these conditions the laying of 80,000 to 100,000 yards of masonry, composed of Cyclopean masonry, concrete and large blocks of granite, was a matter of some difficulty.

The question was discussed at length with the contractors, Coleman, Breuchaud & Coleman, as to the best methods to be pursued to secure the desired progress, and it was decided, after the dam was well leveled up to a convenient height to erect permanent steel towers, on which derricks were to be placed.

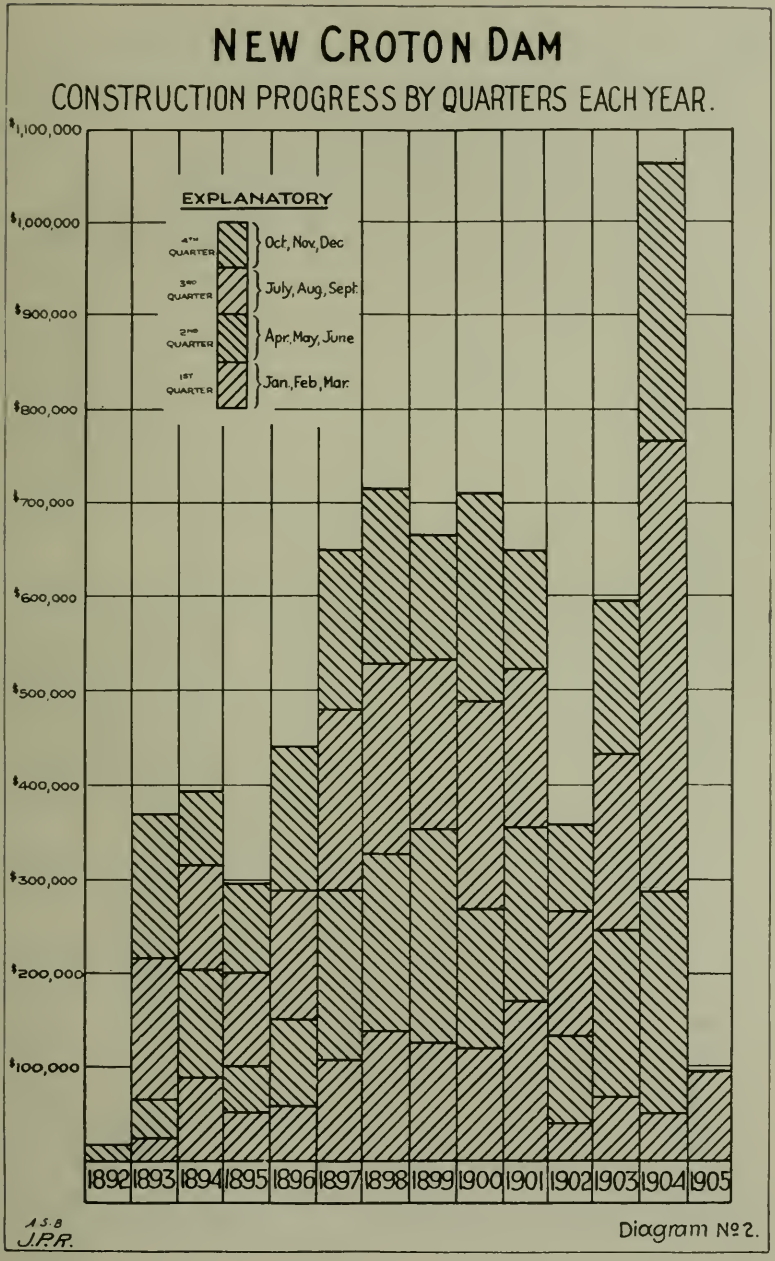
It was believed that the principal loss of time in the construction of a masonry dam was due to, or caused by, the derricks on the wall and by the guys of the derricks commonly used. By placing stiff-leg derricks at the corners of the towers most of the obstructions were done away with, and it was possible to lay masonry under and around the towers over the whole area of the extension without any change of the main plant or raising of the derricks, which would cause delay and expense. It was further considered desirable to construct the



NEW CROTON DAM—STEEL TOWERS USED IN BUILDING EXTENSION.

towers of steel and build them permanently into the heart of the dam, sealing them tightly with concrete and mortar so that the steel work would be thoroughly protected.

There are two 25 x 50-ft. riveted steel towers 50 feet high, which weigh about 40 tons each. Each tower consists of three 3-panel bents made with two vertical posts of T-shaped cross-section, built with pairs of 12-inch channels. There are no horizontal struts at the feet of the posts and those in the upper panels are made of single 8-inch channels. The diagonals are single 3 x 3-inch angles, and those in the lower panels are connected to the vertical posts about 4 feet above their 24 x 24-inch base plates, which are set at El. 80. At El. 73 a pair of 6 x 6-inch horizontal angles 6 feet long were bedded in the concrete at right angles to each other and received the lower ends of four 1¼-inch anchor bolts 7½ feet long, which were carried up through 18 x 18-inch wells filled with concrete and leveled off on top to receive the tower bases. The tower members were delivered separately at the dam and the bents were assembled horizontally on the surface of the ground east of the dam. On a Sunday, when the cableways were not otherwise employed, one of them delivered the bents for one tower to cable No. 2, which swung them to position, where they were held by derricks until the horizontal and diagonal bracing was connected and they became stable structures. The two towers were thus erected on successive Sundays in the early part of August, without causing any interruption to the masonry work. All field connections were made with carefully fitted bolts, and the upper ends of the vertical posts were connected by 15-inch transverse I-beam girders supporting the 12-inch longitudinal I-beams, 5 feet apart on centers, which were covered with 3-inch planks forming the working platform. At each corner of the tower there was seated a stiff-leg 10-ton derrick, with a 30-foot mast and a 40-foot boom. Each derrick was operated by a separate 7 x 10-inch double-drum Lidgerwood hoisting engine on the tower deck. Part of the derricks had the Lidgerwood swinging device geared to the hoisting engines, and the others had independent Rawson & Morrison swinging devices, which could be operated without running the hoisting engines. On one tower steam was supplied to the engines from the main


NEW CROTON DAM
CONSTRUCTION PROGRESS BY QUARTERS EACH YEAR.
$1,100,000
$1,000,000
$900,000
$800,000
$700,000
$600,000
$500,000
$400,000
$300,000
$200,000
$100,000
EXPLANATORY
4TH QUARTER
Oct, Nov, Dec
3RD QUARTER
July, Aug, Sept
2ND QUARTER
Apr, May, June
1ST QUARTER
Jan, Feb, Mar
1892
1893
1894
1895
1896
1897
1898
1899
1900
1901
1902
1903
1904
1905
A.S.B.
J.P.R.
Diagram No 2.

300-h. p. power plant below the dam, and on the other tower, from an auxiliary 200-h. p. plant on top of the hill at the south end of the dam. An accompanying illustration shows these towers and the derricks clearly.

With this arrangement augmented by numerous guyed derricks conveniently placed, for the most part outside of the section of the dam, used for passing stone and concrete, the work proceeded very rapidly, 900 cubic yards per day being frequently laid, and the monthly quantities reaching 15,000 to 17,000 cubic yards.

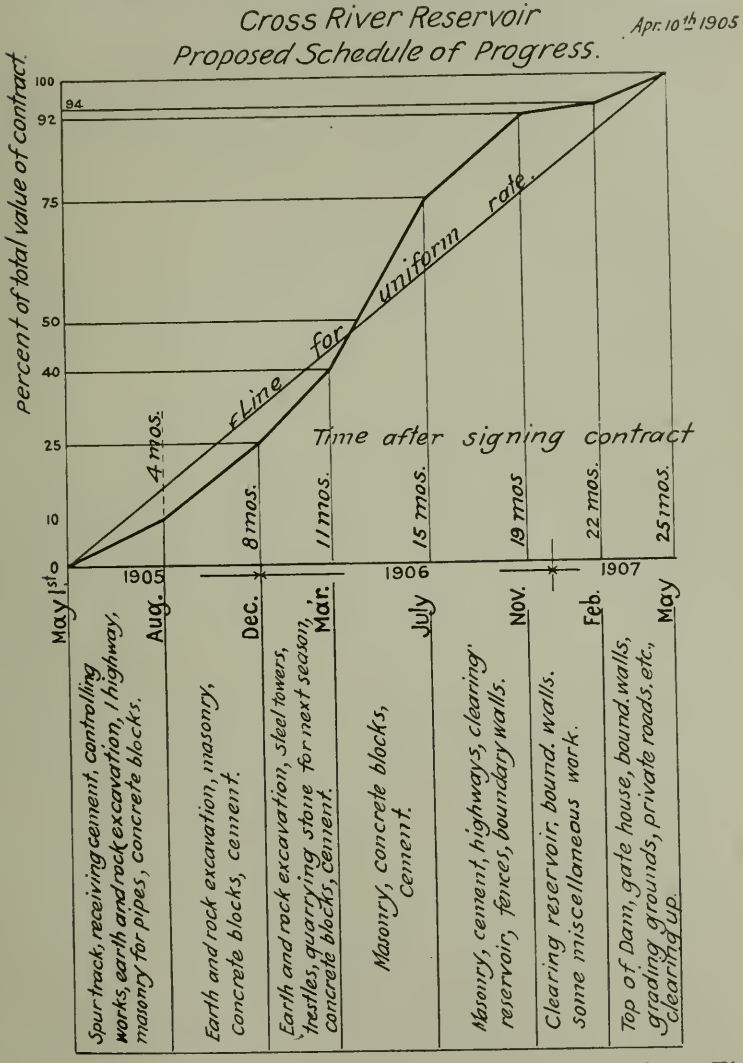
The rate of progress mapped out for the contractors at the beginning of the season and the rate at which the work was actually done is shown in diagram No. 1, an inspection of which will show that the rate of progress was materially greater than what had been expected. In order to still further hasten the progress, one or two mason gangs worked in a night shift.

During the day shift the masonry was built up around the outside of the derrick towers, which are set with their upstream faces 12½ feet back from the dam line. During the night shift, the concrete was deposited in the lower level under the towers, where it could be easily swung in from the derricks and rolled or pushed down to position. To avoid the difficulty of handling large stones here, spawls only were bedded in the concrete. Care was taken to fill in close to the steelwork with fine concrete that would pack solid and seal it tightly.

By the time the masonry reached an elevation about 15 feet above the tower deck, the derricks working in wells, which were later filled up, timber trestle work was erected partly on the back-fill and partly on the downstream face of the dam, on which derricks were placed. This was for the purpose, so far as possible, of keeping the derricks off the wall in order to maintain a steady rate of progress.

The top of the trestle was decked with a solid platform 24 feet wide and 300 feet long, made with 3-inch plank laid on 10 x 12-inch beams. This platform afforded room for the delivery and temporary storage of materials from the surface tracks, and on it were set six boom derricks for unloading and handling materials. With this system the masonry was built to

El. 160, when a new platform was built. Four of the derricks were shifted to it for service in setting the masonry, while the other two remained on the first platform to pass up the materi



als to them. Three more similar platforms will be built at El. 175, El. 190, and El. 205, to carry the work up in successive stages of 15 feet each, the ends of the extension being always

commanded by stationary derricks seated on the old masonry. The upper 15 feet of the masonry is only 18-feet wide and will be built by the two traveling derricks already installed on the top of the main dam, which will work from both ends to the middle of the extension, moving on the top of the finished structure.

It was not practicable to use the steel towers above the height mentioned, for the section of the dam had become too narrow and it was possible by placing the derricks on trestle work, as above described, to practically cover the entire working top of the dam.

The work had been so well planned and the contractor had made such remarkable progress that by the end of December the dam reached the height desired, so that only a comparatively small quantity of masonry was necessary to be laid in January.

About the middle of December the work of closing the opening through the dam, through which the river had been allowed to run during construction was commenced. This was completed about the end of the month. The flood on January 6 prevented the closure of the second opening, which had been used for the railroad track, but the flood subsided about the middle of the month, so that the work was commenced here and the final closure made and the gates permanently closed on January 28.

The water rose but slowly until the latter part of March, when the melting snows soon filled the reservoir to elevation 172, or about 125 feet deep, impounding some 14 billion gallons of water.

The entire dam, except this southerly extension, had been built of rubble masonry laid in mortar, with facings of coursed ashlar. The southerly extension was laid with rubble in concrete, or so-called Cyclopean masonry, with the same facing of coursed ashlar, and the rapid progress is due quite as much to this change in methods of construction as to the steel towers and trestle work, although both contributed their proportionate share to this end. The accompanying diagram, No. 2, shows the rate of progress since the letting of the contract as measured by the amount of the monthly estimates. This includes,

besides the dam, which is the bulk of the work, some other work outside in the construction of roads and repairs to the old aqueduct. This, however, amounts to but a comparitively small percentage of the work at the dam. The paper of Mr. Hill before referred to sets forth in detail the reasons for the changes in the plan of the southerly end of the dam, which necessarily interfered with the progress during the time they were being considered and the work already built torn down.

While it is not claimed there is anything new in the method of building structural steel derrick towers into the dam, as here described, yet it is thought it might be interesting to the members of the association to know what progress had been made under rather trying conditions. These methods proved so satisfactory that in the planning of a large dam, the contract for which is to be let in the immediate future, such towers and trestles have been specified so as to cover practically the entire dam. By this means very rapid progress is expected.

In reply to an inquiry in regard to the diagram in Mr. Smith's paper, President Sherrerd stated that about $380,000 to $400,000 worth of masonry work had been done per year in the two years prior to 1904, and that about $700,000 worth of work had been done in the year 1904. The low point he thought was due to the consideration of the changes in design spoken of in the paper.

President Sherrerd: We have, also, some volunteer matter from Mr. Ericson, chief engineer of the Chicago Water Department, who has offered to give us a little talk on the Chicago water works situation.

THE WATER WORKS SYSTEM OF CHICAGO.

JOHN ERICSON,
City Engineer of Chicago.

The water supply of Chicago is obtained from Lake Michigan and is conveyed through circular brick tunnels to the various pumping stations scattered about the city. The intake shafts, which are located from two to five miles from shore, are protected by crib constructions. The water works system at present consists of:

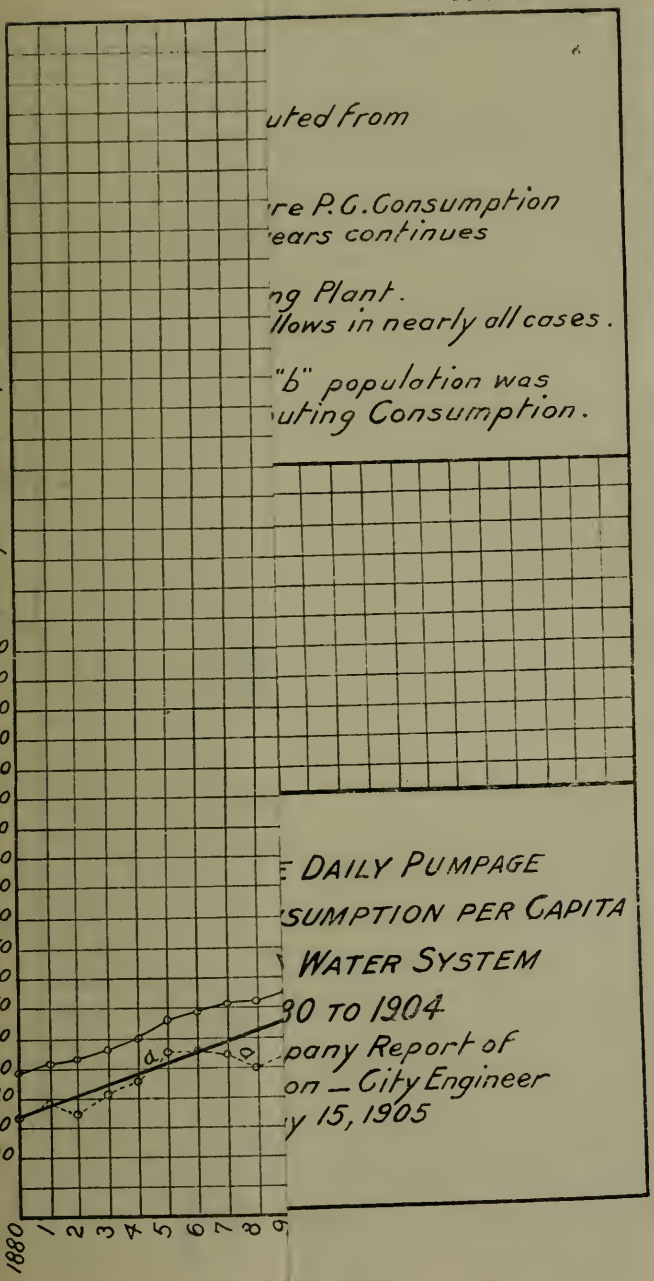
Pumping stations	10
Intake cribs	5
Miles of mains	1,978
Number of fire hydrants	20,349
Number of stop valves	16,095
Number of taps in use	220,000
Number of taps metered	8,102
Number of miles of water tunnels	38
Number of water pipe tunnels under river	17

The pumpage for the year 1904 was at the rate of about 400 million gallons per twenty-four hours, and the average daily per capita consumption 200 gallons.

The city of Chicago was incorporated in 1837 and was first partly supplied with water by the Chicago Hydraulic Company, a private corporation. In 1852 the city, by legislative action, became the owner of the water works, and it is from this date that its history really begins.

The phenomenal growth of the city in population and area made it a difficult task to keep the water works construction up to the requirements. When in 1889 the towns of Lake View and Jefferson, on the north, and Lake and Hyde Park, on the south, added 126 square miles and three independent water systems to the city, the problem became even more complex. The city engineer, who, in addition to the water works system (construction, operation and maintenance), has charge of the bridges, harbors, architectural work (except school buildings), and such special work, can devote but a part of his time to the water supply proposition.

PLATE A.


uted from
re P.G. Consumption
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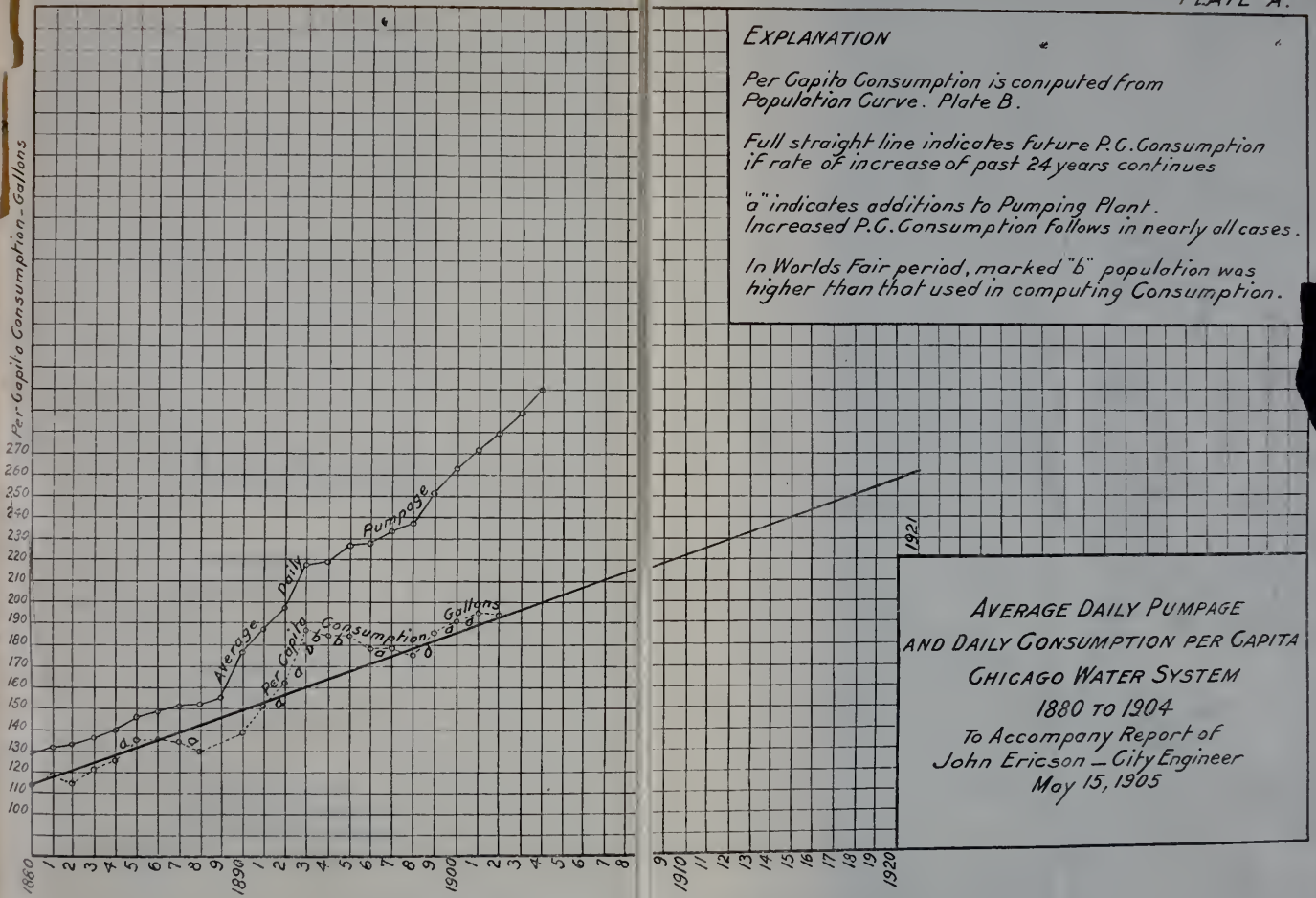
"b" population was
uting Consumption.
DAILY PUMPAGE
SUMPTION PER CAPITA
WATER SYSTEM
30 TO 1904
pany Report of
on — City Engineer
y 15, 1905
Per Capita Consumption - Gallons
270
260
250
240
230
220
210
200
190
180
170
160
150
140
130
120
110
100
1880
1
2
3
4
5
6
7
8

PLATE A.



EXPLANATION

Per Capita Consumption is computed from Population Curve. Plate B.

Full straight line indicates future P.C. Consumption if rate of increase of past 24 years continues

"a" indicates additions to Pumping Plant. Increased P.C. Consumption follows in nearly all cases.

In Worlds Fair period, marked "b" population was higher than that used in computing Consumption.

AVERAGE DAILY PUMPAGE AND DAILY CONSUMPTION PER CAPITA CHICAGO WATER SYSTEM 1880 TO 1904

To Accompany Report of John Ericson — City Engineer May 15, 1905

PLATE B.

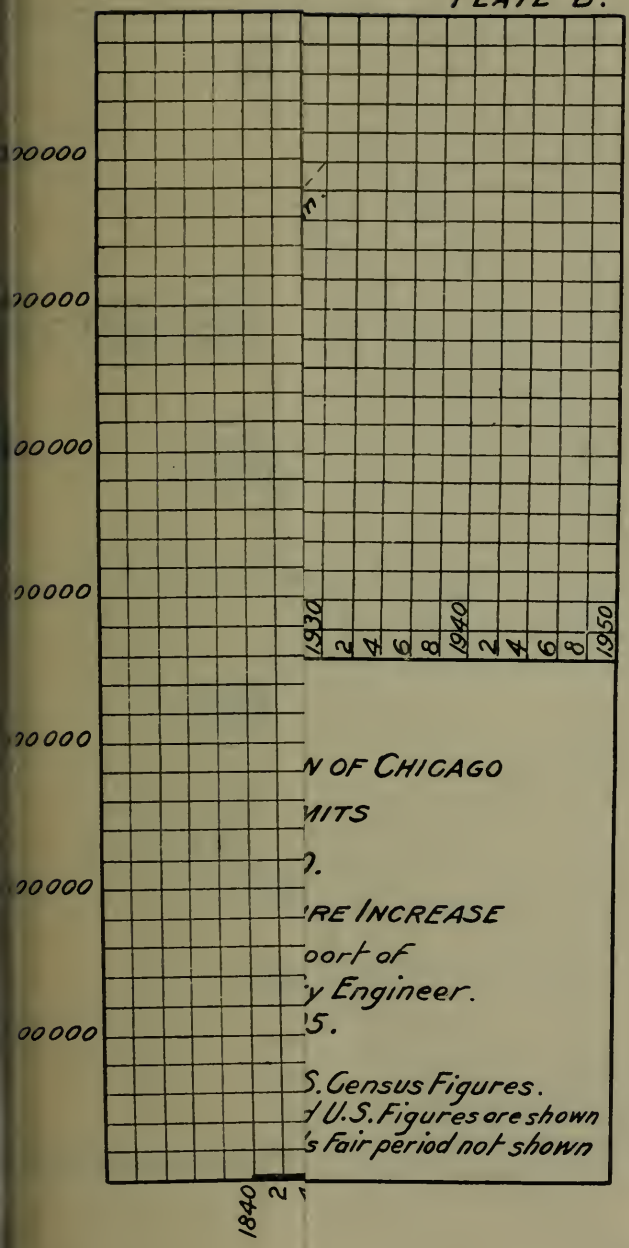
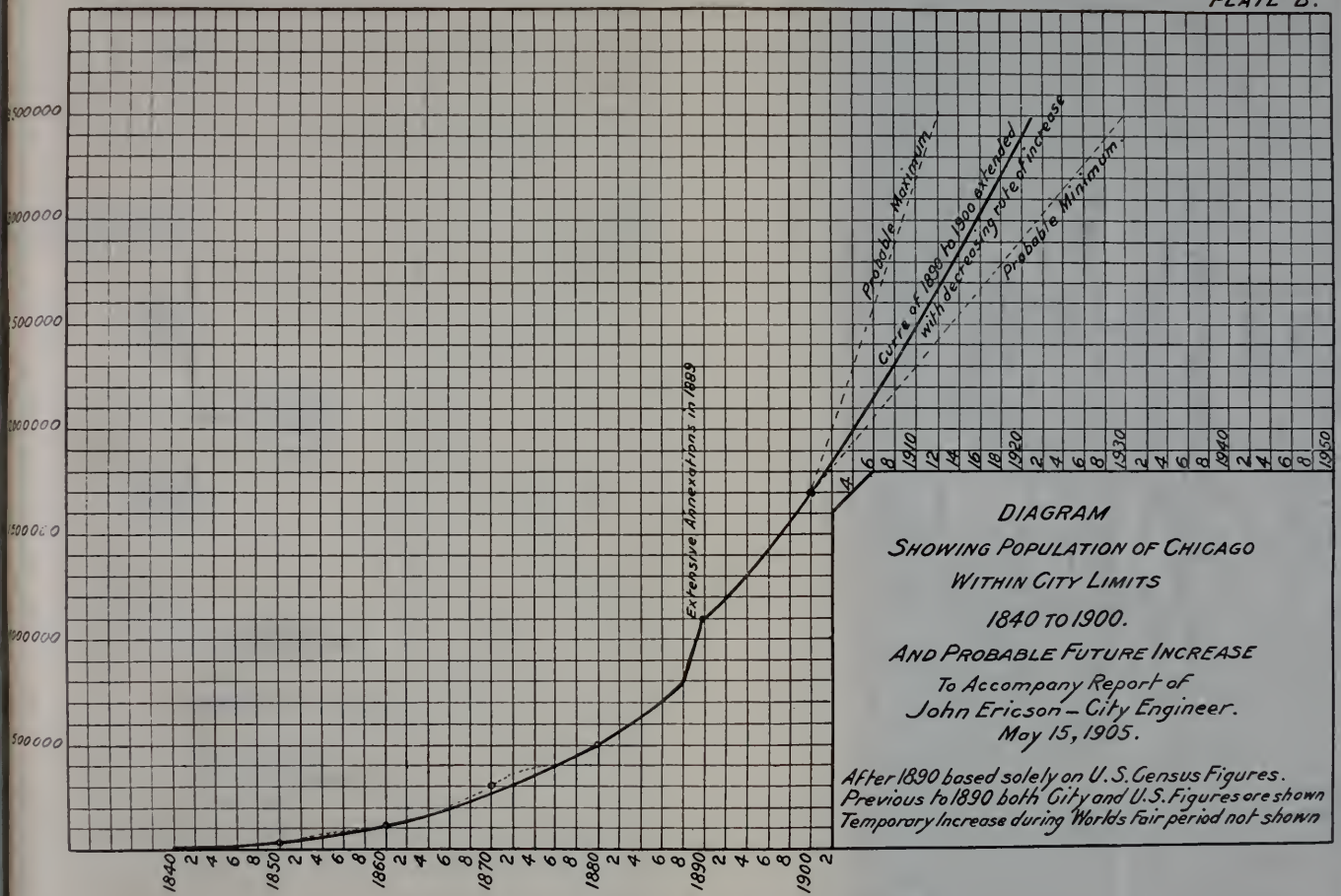
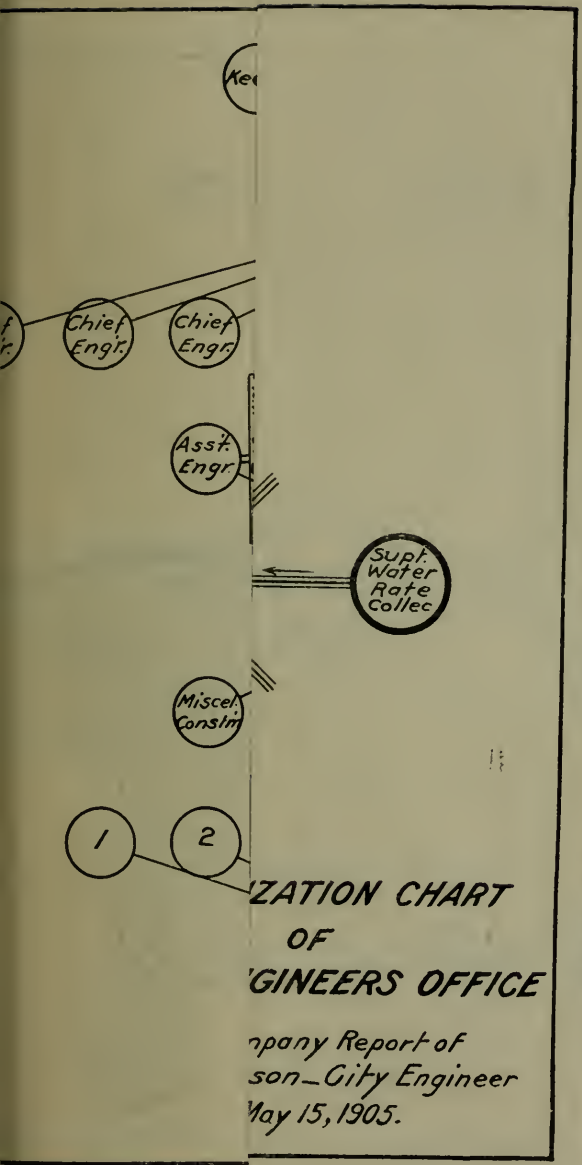

000000
000000
00000
00000
000000
000000
00000
1930
2
4
6
8
1940
2
4
6
8
1950
N OF CHICAGO
MITS
2.
RE INCREASE
oort of
y Engineer.
5.
S. Census Figures.
U.S. Figures are shown
s fair period not shown
1840
2

PLATE B.


Probable Maximum
Curve of 1898 to 1900 extended with decreasing rate of increase
Probable Minimum
Extensive Annexations in 1889
DIAGRAM
SHOWING POPULATION OF CHICAGO
WITHIN CITY LIMITS
1840 TO 1900.
AND PROBABLE FUTURE INCREASE
To Accompany Report of
John Ericson – City Engineer.
May 15, 1905.
After 1890 based solely on U.S. Census Figures.
Previous to 1890 both City and U.S. Figures are shown
Temporary Increase during Worlds Fair period not shown



ZATION CHART
OF
GINEERS OFFICE

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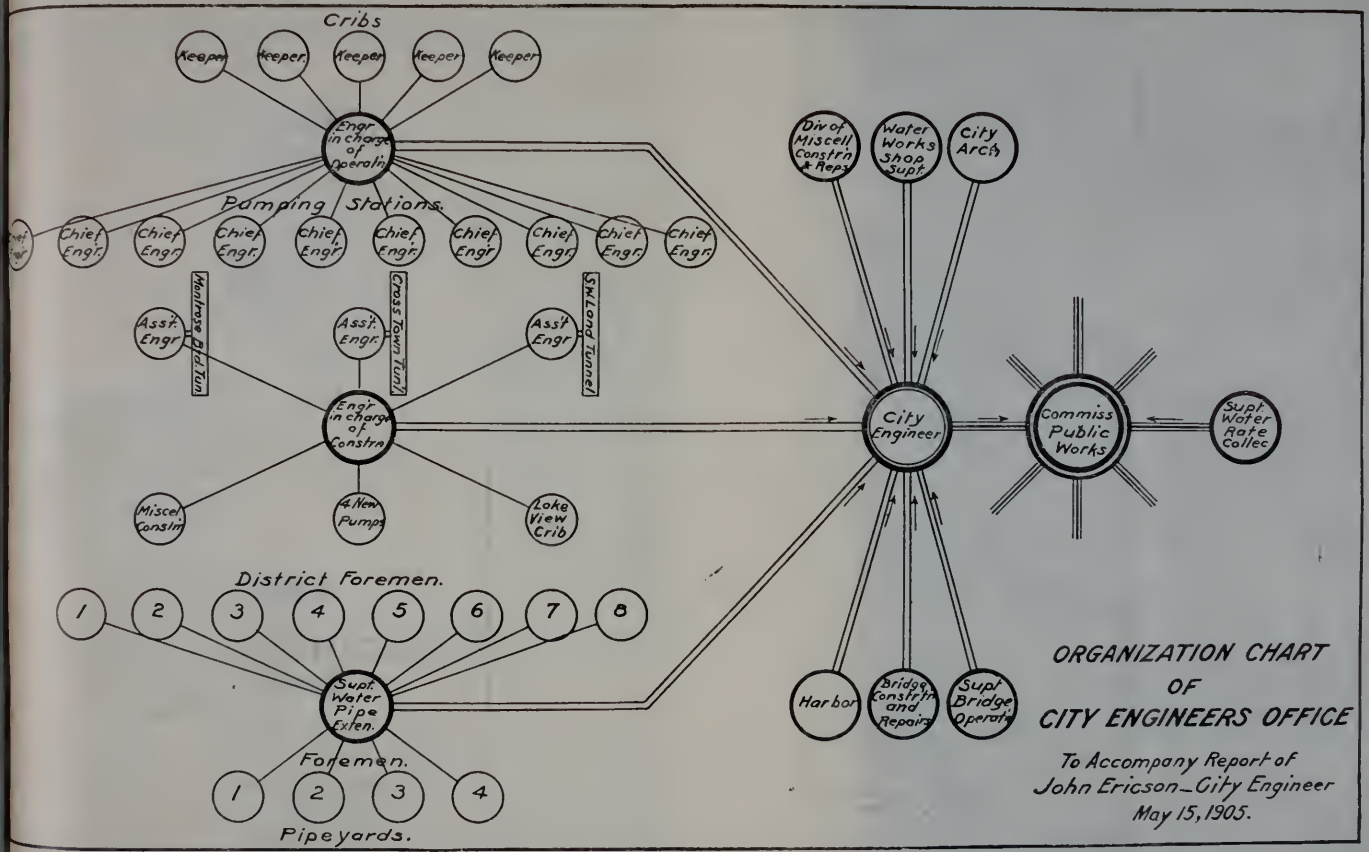
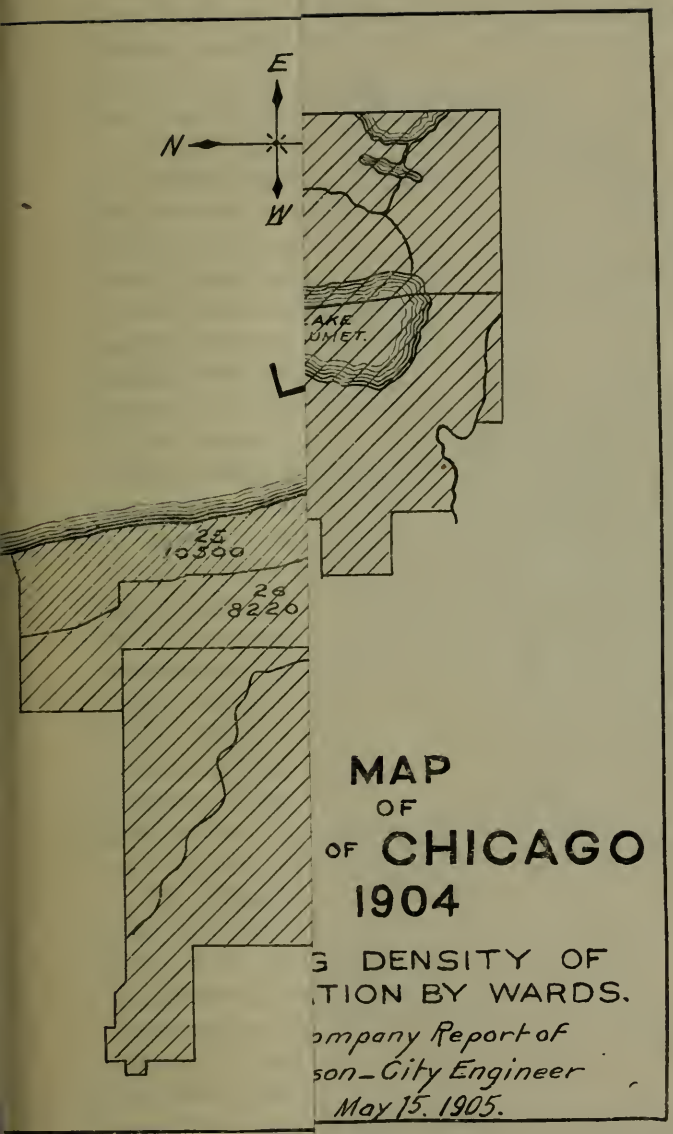
May 15, 1905.


Cribs
Keeper
Keeper
Keeper
Keeper
Keeper
Engr in charge of Operation
Pumping Stations.
Chief Engr.
Chief Engr.
Chief Engr.
Chief Engr.
Chief Engr.
Chief Engr
Chief Engr.
Chief Engr.
Chief Engr.
Montrose 42d Tun
Cross Town Tun
S.N. Long Tunnel
Ass't Engr
Ass't Engr.
Ass't Engr
Engr in charge of Constn
Miscel Constn
4 New Pumps
Lake View Crib
District Foremen.
1
2
3
4
5
6
7
8
Supt Water Pipe Extens.
Foremen.
1
2
3
4
Pipeyards.
Div of Miscell Constrn & Repr
Water Works Shop Supt.
City Arch
City Engineer
Commiss Public Works
Supt Water Rate Collec
Harbor
Bridge Constrn and Repairs
Supt Bridge Operat
ORGANIZATION CHART
OF
CITY ENGINEERS OFFICE
To Accompany Report of
John Ericson_City Engineer
May 15, 1905.

396 d



MAP
OF
OF CHICAGO
1904

G DENSITY OF
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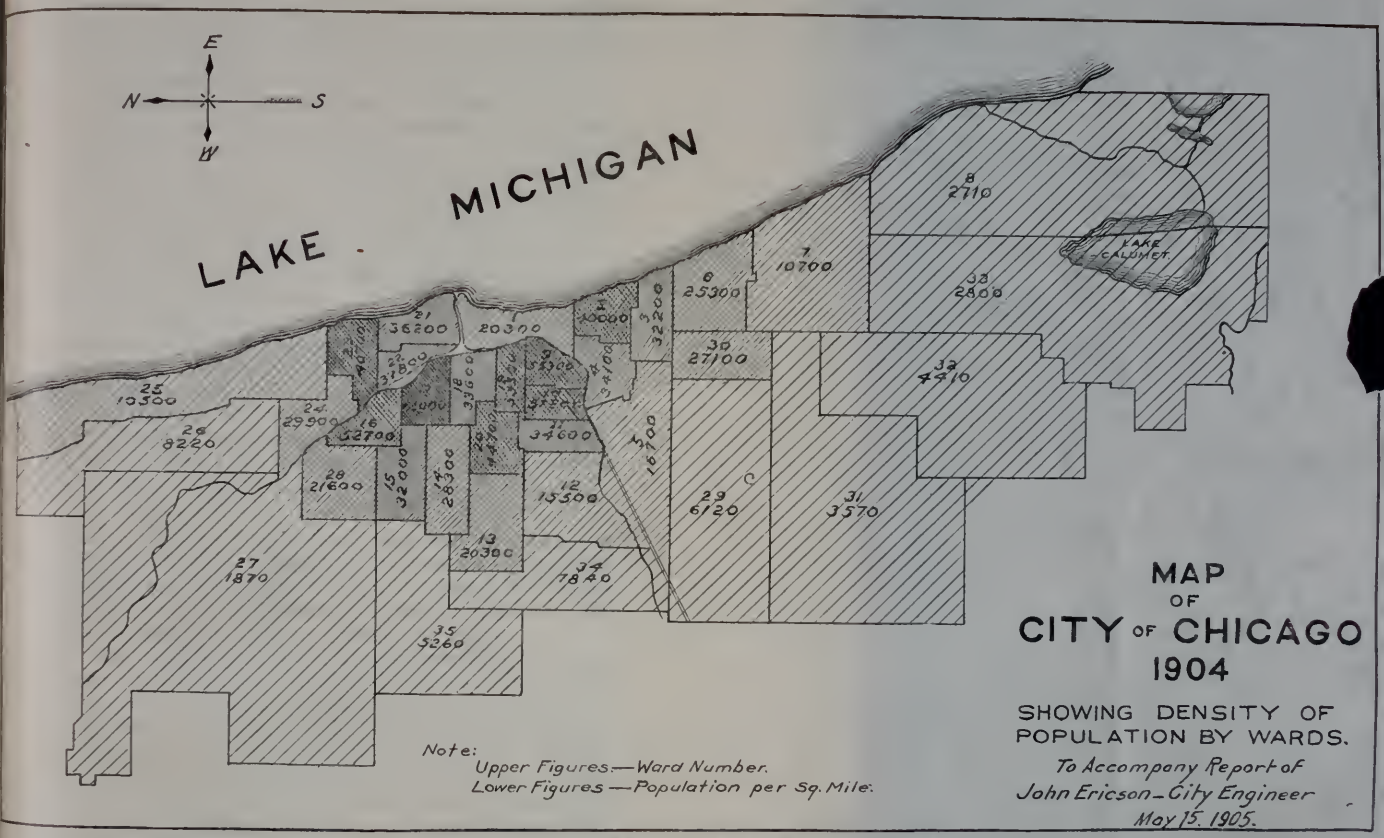
ompany Report of
son - City Engineer
May 15. 1905.


E
N
S
W
LAKE MICHIGAN
LAKE CALUMET
1 10700
2 36200
3 32200
4 40700
5 34100
6 25300
7 10000
8 2710
9 31800
10 33600
11 34600
12 15300
13 20300
14 28300
15 32000
16 32700
17 16700
18 33100
19 33100
20 44700
21 20300
22 31800
23 2800
24 29900
25 10300
26 8220
27 1870
28 21600
29 6120
30 27100
31 3570
32 4410
33 2800
34 7840
35 3260
Note:
Upper Figures — Ward Number.
Lower Figures — Population per Sq. Mile.
MAP
OF
CITY OF CHICAGO
1904
SHOWING DENSITY OF
POPULATION BY WARDS.
To Accompany Report of
John Ericson — City Engineer
May 15. 1905.

In the last few years, in order to unify the various systems, built by the original city and the various annexed towns, over fifty miles of large mains varying in size from 16 to 48 inches have been laid, and the pumping capacity has been increased by about 180 million gallons per day.

Considering the rapid increase in population and in the per capita consumption, however, additions to the systems are constantly required. The additions authorized this year consist of two forty million gallon pumps, one twenty million gallon pump, and one three million gallon pump, also a new tunnel and pumping station to supply the southern part of the city. This latter construction will not be completed until the year 1909. Only a partial installation of pumps is so far authorized.

The present maximum pumping capacity of all the stations is about 495 million gallons per day. When allowing for reserve machinery, not to mention the hourly, weekly or monthly variations, this does not provide for more than a *safe* average daily supply of about 370 gallons per capita, the population being about two million. As the per capita daily consumption for the year 1904 was at the rate of about 200 gallons, it can be seen that the contemplated improvements above mentioned have not been authorized any too soon. When all improvements now authorized and under way shall have been completed, the total nominal pumping capacity of the city will be at the rate of about 690 million gallons per day, or, allowing for reserve machinery, slip and so forth, say about 520 million gallons daily.

The probable per capita consumption in 1909, if the present ratio of increase is allowed to continue, will be about 217 gallons, and the pumpage would then be sufficient for a population of about 2,300,000, if the maximum variations in consumption above referred to be not considered. The population in 1909 will probably exceed this number, so that we shall again, just as soon as these improvements shall have been completed, face the same old condition, a demand for an additional water supply.

Two independent tunnels with pumping stations, one located in the northernmost part of the city and one some-

where immediately south of the Stock Yards, should be considered, and an additional pumping capacity of say fifty million gallons per day added to the South Station above referred to, as soon after 1909 as possible, the tunnel capacity provided being about 100 million gallons per day for this latter station.

After all these additions shall have been completed, the total nominal pumping capacity for the city will be at the rate of about 940 million gallons per day, or, making allowances as before, an average daily constant supply of about 750 million gallons.

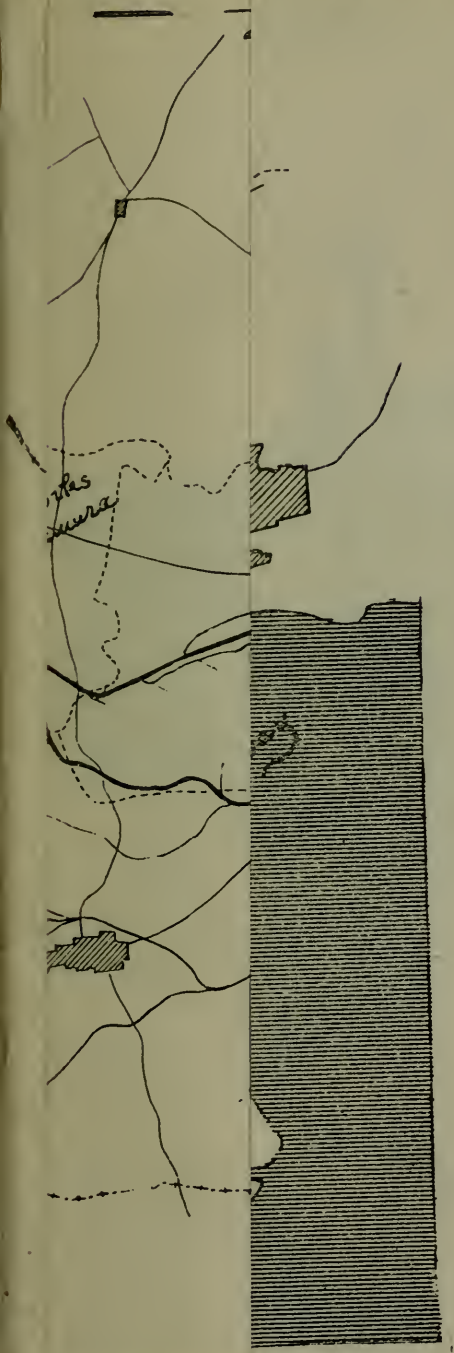
If we assume a per capita consumption of 230 gallons per day, this pumpage would afford a supply of water for a population of about 3,300,000.

If the ratio of increase in population, as well as in the per capita consumption, continues the same in the future as in the past, the city will have this population about the year 1919, but the per capita consumption that year will be about 250 instead of 230 gallons.

It can therefore be seen how serious is the problem of a constantly adequate water supply for the Western metropolis.

Investigations which I made a few years ago convinced me that there is an enormous waste and leakage of the water in Chicago, and as a remedy for this evil, water meters were recommended. This recommendation, however, was not very well received, but I am satisfied that as a matter of necessity water meters will soon be generally installed in the city.

If this recommendation had been acted upon promptly, the proposed extensive improvements could be postponed for several years.



Works Associ

Plan showing Water Shed, Head Works, Water Works Canal etc.
Scale — 1/200000 PLATE I
River Jamna
Water Shed
15,632,000 acres (24 sq. M.)
Head Works at Palwal
Water Works and Irrigation Canal
River Jamna
Fort
Fortress City

TOKYO CITY WATER WORKS.

By Y. Nakajima,
Chief Engineer of Tokyo City.

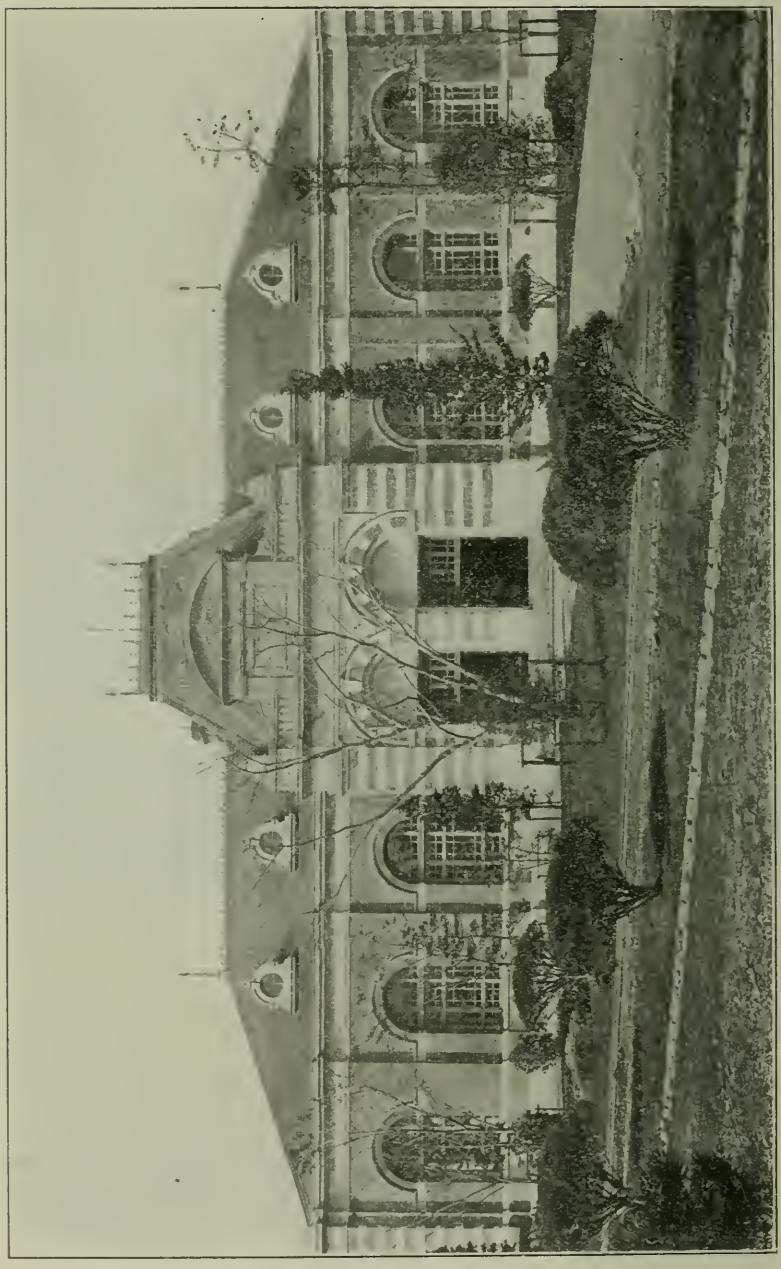
Water was first brought into Tokyo from different sources by open canals, covered stone conduits and wooden pipes about 300 years ago, during the Togugawa Shogun Dynasty.

The new system of water supply is all based upon the most approved foreign practice. The construction was commenced

CEREMONY TO COMMENCE THE WORKS, DEDICATING SAKE (JAPANESE LIQUOR), ETC., TO A DEITY.

in the fall of the year 1892, and the new water was first supplied in the fall of the year 1898.

When the design of the new water works was made, the population of the city was about 1,200,000 and the water is provided for 1,500,000 at the maximum consumption of 4 cu. ft. per person daily; but with small additional works, the supply is supposed to be sufficient until the population reaches 2,000,000. The water is taken from the Tama river about 30 miles from the city (Plate I). The old canal used to supply the



PUMPING STATION AT YODOBASHI WORKS.

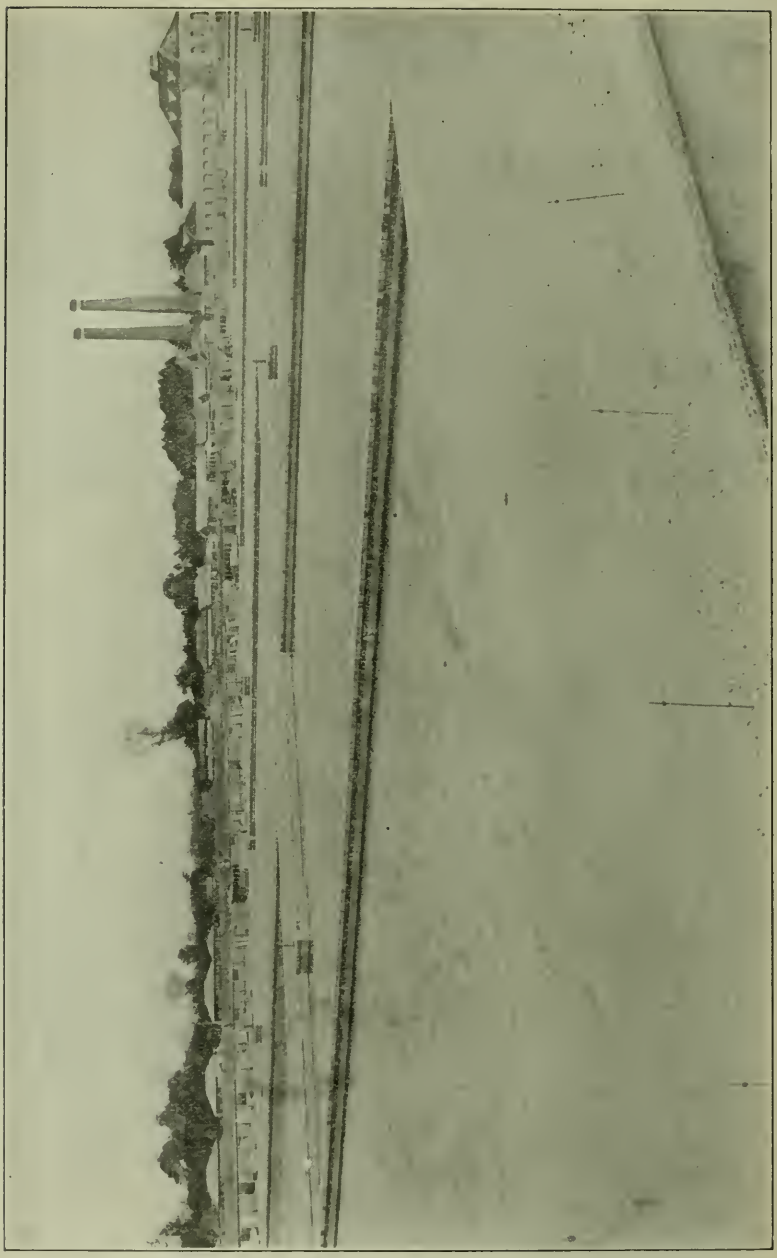
city with water is still in use from the intake at Hamura to about 2½ miles above the Yodobashi works. The latter part of

ARRIVAL OF GUESTS BY WATER WORKS WAGONS AT THE TIME OF THE CEREMONY TO COMMENCE CONSTRUCTION OF THE WORKS.

the canal is a newly made one and is lined with concrete slabs. The water of the Tama river is usually very clear and excellent,

REGULATOR AT HAMURA IN CONSTRUCTION.

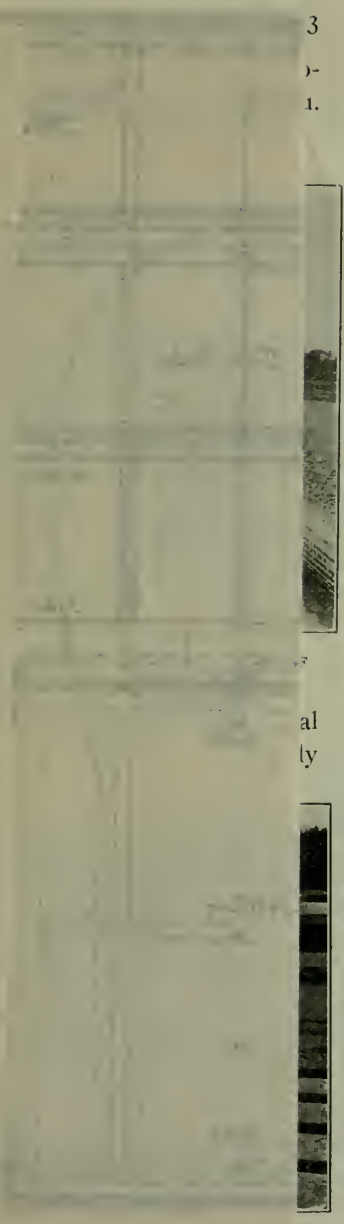
but when the heavy rains fall, it becomes quite muddy and remains so a week or two after the rain. The area of the



GENERAL VIEW OF PUMPING STATION AND FILTER BEDS AT YODOBASHI WORKS.

eral Plan of
Yodobashi Works.

PLATE II

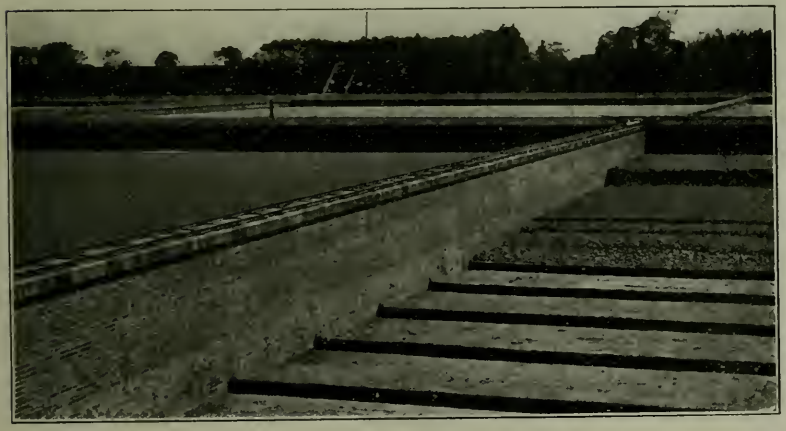


Clean Water Service Reservoir
Pumping Station
Filter Beds
Filter Beds
Filter Beds
Sewer
Reserve Ground
Sand Washing Platform
Sand Washing Platform
Outlet
Inlet
Outlet
Inlet
Reserve Ground
Settling Reservoir
Settling Reservoir
Road
Canal
Canal
Canal
Regulating Gate
General Plan of Yodobashi Works.
PLATE II

watershed is about 5,652,000,000 sq. ft. and is not much inhabited. The minimum discharge of the stream is about 200 cu. ft. per second.

SHOWING THE BANK OF SETTLING RESERVOIR AND THE FEEDING CANALS OF FILTER BEDS.

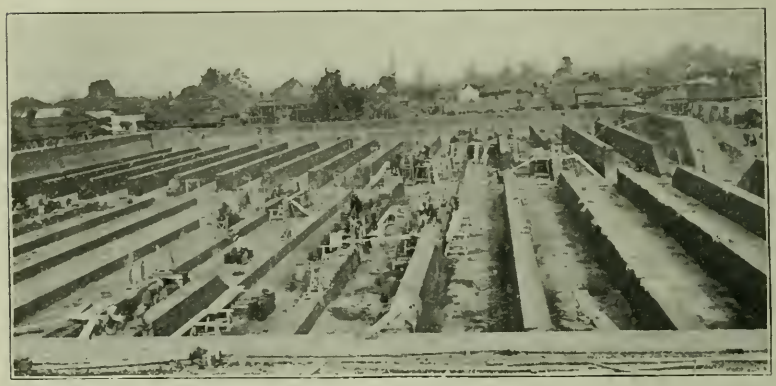
There are three settling reservoirs (Plate II), with a total capacity of 9,000,000 cu. ft.; that is to say, they can supply



FILTER BEDS SHOWING LATERAL DRAINS, GRAVEL, SAND, ETC.

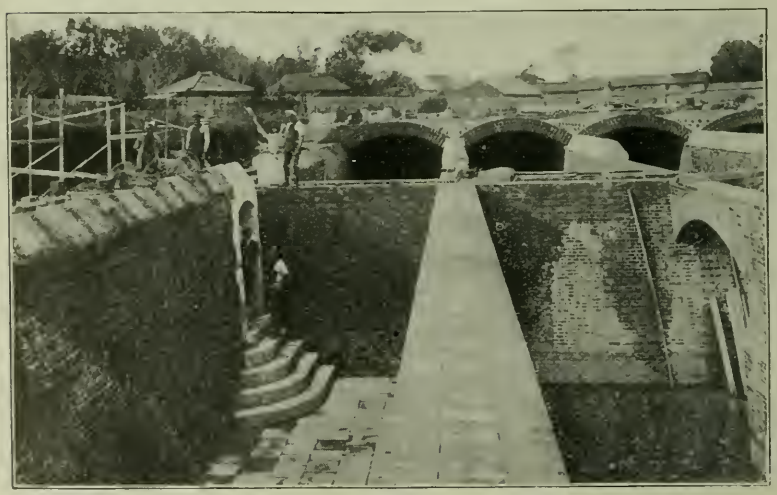
1,500,000 people for 36 hours. These reservoirs are each 720 ft. long by 360 ft. wide and the depth varies from 19 ft. to 20

ft., so that there is a bottom grade of one foot for clearing the mud deposited. The water from the new canal runs into them. The reservoirs can be used either intermittently or continuous-



CLEAN WATER SERVICE RESERVOIR AT YODOBASHI IN CONSTRUCTION.

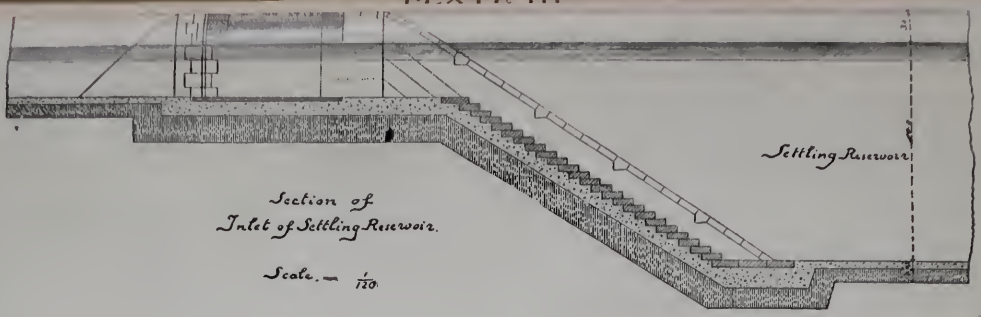
ly. When the heavy rain falls, the water becomes muddy and the simple settlement is not satisfactory, so that last year alum was used for about 30 days.



CLEAN WATER SERVICE RESERVOIR AT YODOBASHI, PARTLY FINISHED.

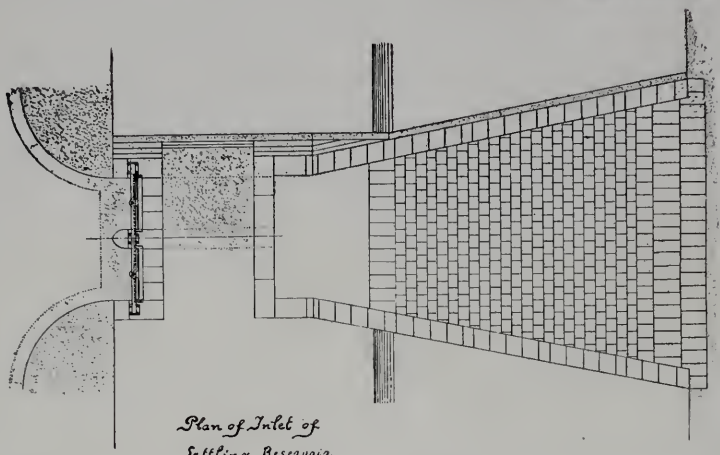
The water is brought from the settling reservoirs into filter-beds (Plate III). There are altogether 18 filter beds, each of

PLATE III



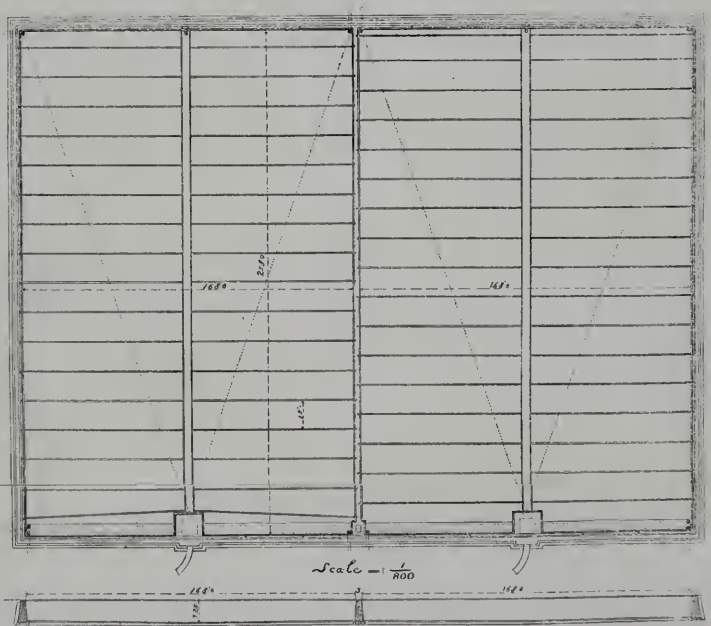
Section of
Inlet of Settling Reservoir.

Scale. — 1/120

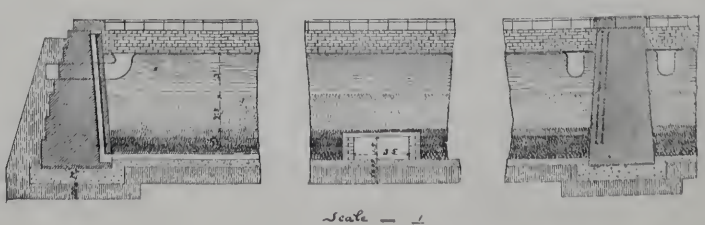


Plan of Inlet of
Settling Reservoir

Scale — 1/120



Filter Beds.



Scale — 1/100

which is 258 ft. long by 168 ft. wide and 9 ft. deep. The total filtering area is about 780,000 sq. ft. The maximum rate of filtration is less than 10 ft. in 24 hours. The depth of sand is 30 inches and the gravel 24 inches. There is an automatic inlet regulator and an outlet weir gauge in each of the beds. There are arrangements to fill the beds with filtered water from their bottoms upwards.

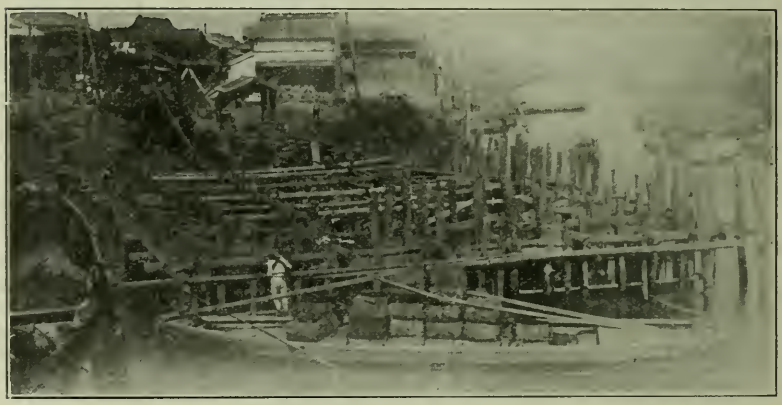
PIPE LAYING 1,100 M. M. IN DIAMETER.

Clean water service reservoirs (Plate IV) are situated at Yodobashi, Hongo, and Shiba. The capacity of the above three reservoirs is exactly the same, namely, 12 hours capacity for 500,000 people, the whole city being divided into 3 equal portions. Each reservoir is divided into two parts and has a covering to prevent dust from polluting the water and to keep out the sun's rays. The water travels in a zigzag path so as to

give it a constant flow and no stagnation of water in the reservoirs.

The whole city is divided into two districts, high and low. The line of division is about 20 ft. above the sea level. The high district contains about one-third of the whole population and the low districts contain the remaining two-thirds.

The water is delivered to the high district by pumps directly from the Yodobashi station; and for the lower parts of the city, it flows by gravitation to the Shiba and Hongo reservoirs, whence it is distributed to the city by gravitation at present.



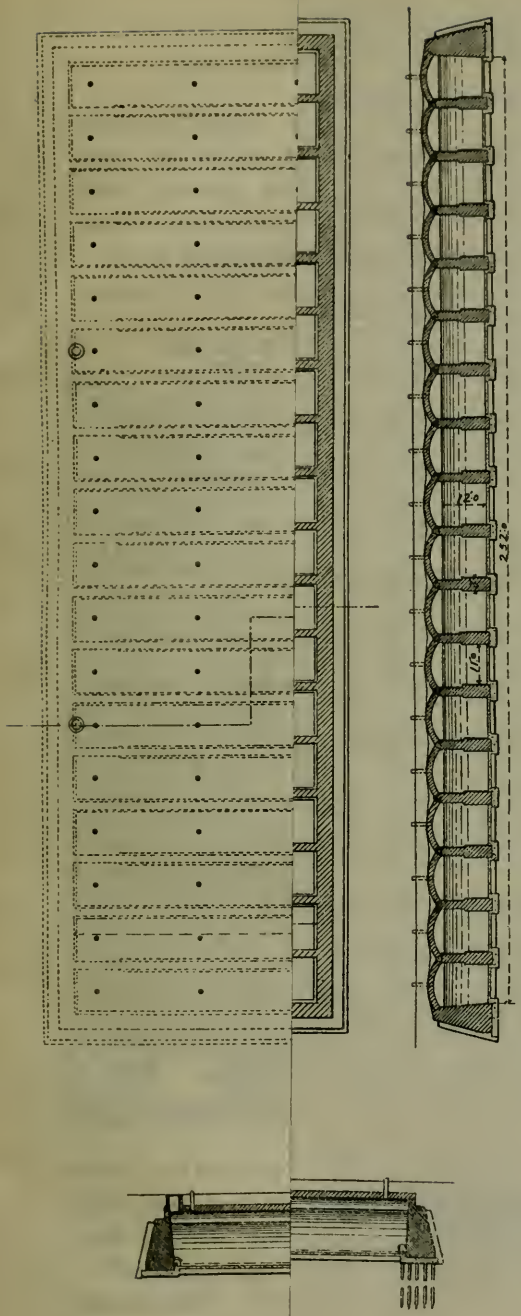
PIPE LAYING UNDER A STREAM.

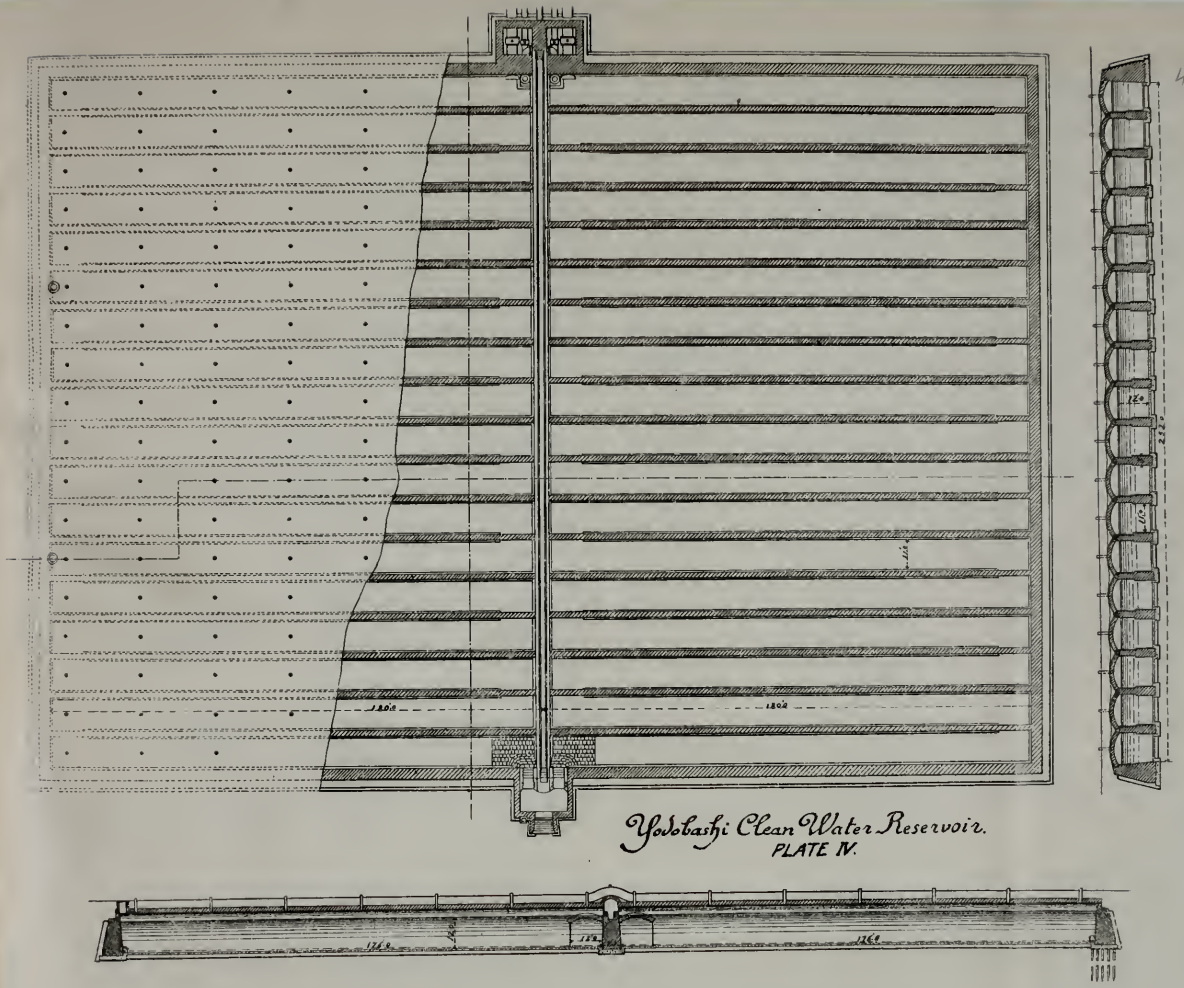
There are four pumps at Yodobashi Station, one of which is reserve. Each pump has a capacity of 1,000,000 cu. ft. of water per 24 hours. The effective head is 80 ft. to 100 ft. above the ground according to localities. There are twelve large Lancashire boilers and two sets of Green's economizers.

There are twelve different sizes of water pipes in use, from 1,100 millimetres to 100 millimetres in diameter and the total length is 407 miles (Plate V). The pipes were imported mostly from Belgium, and Great Britain. Some of the smaller pipes and most of the specials have been made in Japan.

There are 2,728 sluice valves large and small, 4,134 sunk fire hydrants. There are many air and safety valves. The large sluice valves, air valves and safety valves were imported from abroad, while the small valves and fire hydrants were

406a





Yodobashi Clean Water Reservoir.
PLATE IV.

made in Japan. There are 235 district meters which can be used also as fire hydrants. Water meters were all imported from America, England, Germany, and France, and the total number in use at present is 29,556.

All of the plumbing work is done by the City employes at the expense of the water consumers. The lead pipes have been

Quantity of Water supplied in cubic feet per day during the year 1904.

Date	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	2540436	2750508	2589134	2646846	2799347	3243114	4180114	4353306	3877800	3886404	3378468	2900356
2	2471786	2829474	2537470	2733090	2902202	3613146	4222828	3923078	4581044	3615338	3135437	2873630
3	2764011	2621276	2825430	2673054	3373762	3815682	3887396	3512130	3695024	3447921	3130217	3166111
4	2473620	2778264	2647708	2728002	2937218	3752436	3891580	3988081	3941838	3787234	3272140	3144239
5	2642944	2611029	2490648	2569158	2941558	3776811	4577514	3506176	4090167	3121347	3418310	3165470
6	2782780	2607064	2657816	2771632	3164325	3088008	4207736	4313886	3946332	3731230	3223446	3011774
7	2763367	2661000	2650725	3067332	3085946	3457753	4353560	4644702	4376820	3868720	3383906	3013942
8	2870442	2578558	2907747	3003768	3403814	3643575	4174762	4256070	4178373	3723547	3345372	3175706
9	2779011	2830317	2753130	2945912	3436772	4136824	3537690	4285786	3734077	3422822	3411614	3077005
10	2713477	2781810	2581810	2716327	3461469	3776026	3145260	4228860	4140116	3131873	3347382	3015558
11	2633565	2678160	2431422	3236325	3237373	3004710	3602754	4381872	4218578	4228041	3264132	3071187
12	2908845	2526444	2578446	3028033	3441684	3227788	3854640	4228860	3778222	3573654	3315749	3083742
13	2429823	2678110	2274874	3052344	2777034	3144147	4497234	4316382	4156585	3273708	3434652	2747352
14	2628270	2621682	2725202	3166386	2719632	3823036	4342117	4345756	4035578	3277763	3324427	2747352
15	2795412	2567734	2687824	2522170	2877282	3803066	3373610	4207768	4028694	3775086	3150186	2720512
16	2334486	2337397	2666733	2321047	3217347	3068478	3275870	4050712	3269734	3754158	3273344	3002800
17	2470570	2506176	2761762	2953384	2962347	3640373	4346302	4078656	4064776	3166614	3133135	3322335
18	2705686	2530125	2574088	2788825	2876717	3033337	3855858	4344784	4434482	3221476	3236212	3152620
19	2432264	2706470	2479116	2763435	3012793	3346317	4207334	4271061	3524472	3877548	3242361	3100115
20	2703616	2640720	2656143	2767858	3226614	3007516	4236186	4145808	3607772	3466620	3347338	3175706
21	2682793	2737230	2633383	2768740	3002459	3301752	4282072	4343666	3972266	3612222	3347613	3018126
22	2726188	2578876	2640306	3083259	3071776	3478728	4345270	4466140	4331216	3514372	3390366	3321157
23	2508210	2788672	2720383	3360304	3397872	3731076	4159532	4327758	3911206	3483246	3003076	2897700
24	2662088	2614970	2777330	3375616	2663082	3117630	3548541	4346401	3750778	3110374	3078214	3042284
25	2846476	2700362	2719116	2743822	2662200	3347010	3127131	4223782	3252178	3370936	3178045	3118337
26	3378606	2807350	2788640	3103772	2703882	3828697	4277456	4074150	3370228	3691247	3077804	3088777
27	3348370	2491713	2594968	2836332	3291300	4114545	4282072	3878672	4023897	3430116	3166111	3202730
28	3402486	2573386	2570632	3030168	3077160	3678427	4208310	4217010	3642632	3347232	3162413	3286937
29	3461886	2880724	2526370	3070836	2937472	4171403	4075322	3991260	3672343	3386317	3033151	3467602
30	2994440		2778187	3168666	2983376	4067024	4466820	3900737	3638834	3457013	3078738	3343848
31	2902224		2711872		3133162		3542404	3562854		3460374		3287858
Total	85723403	77022376	81607797	88123940	94279285	96370347	124034153	127118370	116477224	107643208	97058188	96619785

made at Tokyo by a native firm and the total amount of lead pipes used is 5,356 English tons. All the brass fittings have been made in Japan.

The total cost of the works up to date is 8,260,936 yen ($4,130,468). City waterworks bonds at 6 per cent. interest were issued from time to time to raise the money. They are redeemable within 30 years from date of issue. The Imperial

Government made a grant of 2,942,000 yen ($1,471,000) to the whole works for the purpose of paying interest on bonds, and the above amount is given at the rate of 150,000 yen ($75,000) per year.

Families using the new water are 139,000 in number, and there are also 20,529 meters for offices, hotels, factories, large

Quantity of Water supplied in Cubic Yards during the year 1903.

Date	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	1713417	2077168	2428200	2407196	3176811	3171674	2570760	3601476	3375227	3242760	2862326	2513950
2	2266302	2437727	2928517	2412517	3201278	3211277	3150720	2547744	3478766	3018672	3030618	2661012
3	1914668	1907847	2277630	2366191	3374778	3183677	3167715	3060024	4147286	3167740	2871774	2434691
4	2178349	2083728	2247786	2383755	2971212	2783538	2563728	3887724	3792756	3310436	2943814	2513148
5	2238266	2083728	2491628	2372144	3142244	3157337	2724876	4046672	3772751	3276520	2768258	2741076
6	2226760	2165694	2247846	2358398	2789552	3235374	2727878	4201146	3706606	3300069	2777316	2722324
7	2154720	2360784	2434142	2510727	2561752	3156734	2572732	3805318	3338321	3128432	2887774	2586349
8	2312470	2238572	2404478	2428840	3177810	3223464	2663666	3874864	4287752	2697272	2661060	2626834
9	2136555	2367726	2323342	2378706	2816280	2768419	3114270	4014350	3447683	3123802	3022716	2701068
10	2487376	2425624	2362692	2503500	2783873	3018206	3400578	4043156	4308126	2819660	2790760	2765736
11	2893310	2300788	2259124	2208356	3043602	3104274	3357862	4023772	3866380	3351362	2800336	2573280
12	2354710	2245558	2312796	2635765	2910492	3025634	3240918	4161816	3615180	2617981	2863328	2687580
13	2274770	2213818	2207618	2574054	2932320	2781734	2743547	3854752	2935110	2767547	2788848	2687580
14	2274770	2324530	2372603	2440270	2581068	2766084	3003197	4054379	3107208	3174134	2687127	2664137
15	2274770	2273560	2146271	2317379	2378340	2830794	3251496	3723238	2775445	3148162	2813575	2662494
16	2221186	2278060	2216466	2352608	2737872	2655504	3386032	4007871	3672748	2832987	2741388	2734080
17	2274872	2400196	2288266	2373731	3142062	2768825	4151750	3764522	3577406	2662416	2604249	2476310
18	2263184	2336419	2297114	2705068	2666276	2734748	3553430	3826724	4015940	3162006	2640294	2588145
19	1973004	2434861	2473478	2783276	2347256	2887146	3547778	3727246	2971086	2705467	2855926	2687580
20	1780282	2230870	2123113	2655697	2758882	2534257	3020816	3743870	2774662	3405778	2637207	2586564
21	2338144	2401900	2547148	2380632	2748360	3088814	3470138	3424008	3258252	2792260	2639134	2633334
22	2411681	2554173	2227230	2548735	2863152	2573202	2706624	3671801	2767744	2726922	2744832	2477814
23	2355486	2654772	2175769	3221670	2771612	2777252	3176528	3417593	2706944	2744330	2521833	2601178
24	2466495	2347432	2156072	2872854	2772610	3171748	3337560	3718756	4201152	3161322	2740470	3162498
25	2414111	2568002	2427924	2700686	2712578	3047772	2637328	4123841	3523266	3048746	2744832	3078148
26	2334466	2330786	2104622	2726798	2854082	2736087	3672748	3728860	3583304	2874618	2517867	2764457
27	2345840	2473837	2173506	2914877	2732302	2656074	3816675	3302080	3024162	2547224	2567012	3185327
28	2158452	2350244	2434704	2633311	2613813	2748540	3878884	3680286	3362424	2680122	2778370	3068178
29	2468488		2350620	2534337	3140516	3603890	3716672	3655264	3205725	2798756	2738072	3004784
30	2435526		2496580	2716075	2950551	3012348	3756786	3736753	3502428	2367092	2872536	3011595
31	2120382		2365980		2674326		3462318	3776028		2420862		3681686
Total	70697337	65255768	71605335	76668035	87917772	87422694	87736607	104794184	92162517	83577114	85374141	

families, laundries, etc. The total income of this year is expected to be 653,804 yen ($326,902), while the expenditure will be 198,988 yen ($99,494).

The water charge for one faucet is 5 yen ($2.50) per year for a family with five persons, and for each extra person 50 sen (25 cents) in addition a year. Each extra tap is charged

Plan showing Mains and Distribution Pipes of the City of Tokyo.

Scale — 1/40000.

Plate V

Diameter	Length in Miles
1100	8.1
610	2.3
508	6.6
457	1.9
410	4.1
356	6.7
305	8.7
254	12.3
203	28.7
152	36.2
102	117.3
76	184.1

3 yen ($1.50) per year in addition. For a poor family taking water from street fountain the charge is 1.5 yen (75 cents) per year. Water can be taken by meter and the meters are rented from the water works office at the following rate. The rent varies from 2.40 yen ($1.20) per year for 12 millimetre diameter to 52.80 yen ($26.40) for one of 250 millimetre diameter. The charge for water by meters is 70 sen (35 cents) for users of 20 cu. metres per month and 3 sen (1½ cents) for each extra cu. metre. For public baths the charge is 2 sen per cu. m. and for sprinkling, it is 5 sen (2½ cents) per cu. m.

I think the above charge is one of the cheapest in the world for the filtered water.

LIST OF MEMBERS

AMERICAN WATER WORKS ASSOCIATION.

HONORARY.

	Date of Membership.
BEMENT, R. B. C.	
St. Paul, Minn	1888
CAMERON, W. L.	
Sixth and Quintard Ave., Anniston, Ala	1881
FOSTER, J. F.	
Room 43, 92 La Salle St., Chicago, Ill	1881
HOLLY, IRA A.	
129 East 59th St., New York City	1881
HOLMAN, M. L.	
1324 Chemical Bldg., St. Louis, Mo	1881
NAKAJIMA, Y.	
Imperial University, Tokyo, Japan	1887
WATTS, SYLVESTER	
St. Louis, Mo	1881

ACTIVE.

ADKINS, B. C.	
Water Comr., 312 City Hall, St. Louis, Mo	1900
AFFLECK, JOHN A.	
Water Comr., Harrisburg, Pa	1899
AHERN, JOHN T.	
Supt. Water-Works, Nashville, Tenn	1901
AIKEN, HENRY M.	
Res. Mgr. Water Co., Knoxville, Tenn	1904
ALEXANDER, W. A.	
1007 Ross Ave., Wilkinsburg, Pa	1890
ALDERMAN, C. L.	
Manager Water Co., Big Springs, Tex	1904
ALVORD, JOHN W.	
Cons. Engr., 1207 Hartford Bldg., Chicago, Ill	1899
AMSBARY, F. C.	
Mgr. Champagne & Urbana Water Co., Champagne, Ill.	1902
ANDERSON, J. F.	
Meter Supt., 1737 Washington St., Kansas City, Mo	1903

	Date of Membership.
ANDERSON, JOHN	
Secy. Water-Works, Binghamton, N. Y.	1903
ANDERSON, L. W.	
City Engr., Grand Rapids, Mich.	1901
ANDREWS, LEWIS P.	
Pres. Water & Light Co., Sedalia, Mo.	1904
ARTINGSALL, SAMUEL G.	
239 Rialto Building, Chicago, Ill.	1890
BABCOCK, S. E.	
Hydraulic Engr., 54 Mann Bldg., Utica, N. Y.	1886
BACOT, R. C.	
Insp. Meter Dept., P. O. Box 221, Port Chester, N. Y.	1894
BAIN, ERNEST B.	
Supt. Wake Water Co., Raleigh, N. C.	1904
BAKER, M. N.	
Assoc. Editor Engineering News, 220 Broadway, New York, N. Y.	1903
BANCROFT, LEWIS M.	
Superintendent Water-Works, Reading, Mass.	1905
BANCROFT, P. T.	
Supt. Water-Works, Rock Island, Ill.	1903
BARKER, W. H.	
Sec. of Board of Water-Works Trustees, Sioux City, Ia.	1903
BASSETT, GEORGE B.	
Civil Engr., 290 Terrace, Buffalo, N. Y.	1898
BAUMAN, C. V.	
Water Comr., Newark, N. J.	1900
BEARDSLEY, JOSEPH C.	
1200 Scofield Bldg., Cleveland, Ohio	1903
BECKER, GEORGE	
City Engineer's Office, Seattle, Wash.	1905
BEMIS, EDWARD W.	
Supt. Water-Works, 178 Kensington St., Cleveland, O.	1903
BENNETT, THOS. H.	
Oswego, N. Y.	1898
BENZENBERG, G. H.	
Cons. Engr., 436 Jefferson St., Milwaukee, Wis.	1888
BERRY, J. P.	
Supt. Water-Works, Waterloo, Ia.	1896
BETTES, CHARLES R.	
Chief Engr. Queens Co. Water-Works, Far Rockaway, L. I., N. Y.	1901
BRIGHTMAN, HORACE I.	
Sec. Staten Island Water Supply Co., 50 Broadway, New York, N. Y.	1902

Date of Membership.

BINDER, FREDERICK C.
Asst. Supt. and Treas. Water Co., Jefferson City, Mo.. 1904

BISHOP, JOHN L.
Sec. and Supt. Water-Works, Salina, Kan..... 1893

BISSET, EDWIN H.
Metals Broker, 717 Union Bank, Winnipeg, Man..... 1898

BOARDMAN, ARTHUR EDWIN
Pres. Tampa, Fla., Water-Works Co., Room 1707-41 Broad St., New York, N. Y..... 1903

BOARDMAN, W. H.
Civil Engr., 2203 E. Dauphin St., Philadelphia, Pa..... 1893

BOEH, W. H.
Chief Engr. Water-Works, Cincinnati, Ohio..... 1900

BOGART, JOHN
Civil Engr., 16 Exchange Pl., New York, N. Y..... 1892

BOLGER, F. E.
Secretary Water-Works, City Bldg., Springfield, O..... 1903

BOLLING, CHARLES E.
Supt. Water-Works, Richmond, Va..... 1891

BOND, JOSEPH A.
Civil Engineer, Wilmington, Del..... 1888

BOOKER, GEORGE E.
Chief C. S. V. W. W. Co., 126 Stockton St., San Francisco, Cal..... 1891

BRACKENRIDGE, GEO. W.
Pres. Water Co., San Antonio, Tex..... 1888

BROOKS, ISAAC W.
Pres Water Co., Torrington, Conn..... 1889

BROTHERTON, CHARLES F.
Mgr. Water Co., Ashtabula, Ohio..... 1904

BROUGH, WALTER CONSTANTINE
C. E. Goderich, Can..... 1897

BROWN, CHARLES CARROLL
Consulting Engineer and Editor Municipal Engineer, Commercial Club Bldg., Indianapolis, Ind..... 1905

BROWN, C. ARTHUR.
Sanitary Engineer, Lorain, Ohio..... 1905

BROWN, CALVIN S.
Water Comr., 54 Canal St., Chicago, Ill..... 1882

BROWN, LEW O.
Supt. Water-Works, Carthage, Mo..... 1902

BUNTING, N. W.
Elmira, N. Y..... 1901

	Date of Membership.
BURLEIGH, JOHN J.	
Sec. and Treas. Merchantville Water Co., 5th and Market Sts., Camden, N. J.	1895
BURNETT, M.	
Supt. Water-Works, Paducah, Ky.	1889
BURNS, T. W.	
City Engineer and Supt. Water-Works, Fairbury, Ill.	1905
CAHILL, STEPHEN.	
Supt. of Water-Works, Manistee, Mich.	1890
CAIN, W. L.	
Supt. of Water Co., Tyler, Texas.	1903
CAIRD, JAMES M.	
Chemist and Bacteriologist, 271 River St., Troy, N. Y.	1900
CALHOUN, H. L.	
Sec. Water-Works, Fort Worth, Texas.	1904
CAMPBELL, CHARLES H.	
431 Equitable Bldg., Atlanta, Ga.	1895
CAMPBELL, JAMES J.	
Supt. Water-Works, Menominee, Mich.	1902
CAPPELEN, F. W.	
Cons. Engr., 610 Globe Bldg., Minneapolis, Minn.	1893
CARLSON, J. A.	
Water Comr., Stromsburg, Neb.	1904
CARROLL, DANIEL W.	
Battalion Chief and Supt. Water, 146 Pine St., Detroit, Mich.	1903
CARROLL, EUGENE	
Chief Engr. and Supt. Water Co., Butte, Mont.	1904
CASE, E. W.	
Colorado Springs, Colo.	1902
CASE, L. N.	
Mgr. and Sec. Water and Light Dept., Duluth, Minn.	1889
CAULFIELD, JOHN.	
Sec. Water-Works, St. Paul ,Minn.	1887
CHAPIN, L. E.	
Cons. Engr. Water-Works, Canton, Ohio.	1899
CHARLES, S. A.	
San Diego, Cal.	1894
CHATHAM, J.	
Supt. Water-Works, Iowa City, Ia.	1892
CHIPMAN, WILLIS	
Civil Engr., 103 Bay St., Toronto, Can.	1888
CHISHAM, J. M.	
Dir. Water Co., Atchison, Kan.	1902
CLARK, D. H.	
Supt. City Water-Works, Ironton, Ohio.	1904

Date of Membership.

CLARK, H. W.
Treas. and Genl. Mgr. Clear Water Co., Mattoon, Ill..*1895-1903
CLARK, J. V.
Supt. Citizens' Water Co., Washington, Pa..... 1903
CLARK, RICHARD
Supt. Water-Works, Merritton, Ont..... 1905
CLAYTON, R. M.
City Engr., Atlanta, Ga..... 1891
COBB, CHARLES H.,
Supt. Water-Works, Kankakee, Ill..... 1904
COLE, EDWARD S.
Hydraulic Engr., Room 21-I, 220 Broadway, New York, N. Y..... 1902
COLE, JOHN A.
Hydraulic Engr., Old Colony Bldg., Chicago, Ill.....*1889-1902
CONARD, W. R.
Inspector of Materials, 1102 High St., Burlington, N. J.. 1904
CONLIN, F.
Water-Comr., 355 Market St., Bethlehem, Pa..... 1904
CONNOR, F. J.
Supt. Water-Works, Faribault, Minn..... 1900
COOK, F. S.
Asst. Engr. Croton Aqueduct Commission, 26 Landscape Ave., Yonkers, N. Y..... 1904
COOK, T. R.
Superintendent Water-Works, Toledo, Ohio..... 1897
CORR, ANDREW S.
Inspector of Cast Iron Pipe, 146 Washington St., Phillipsburg, N. J..... 1905
CRANDALL, WILLIAM S.
Editor Municipal Journal and Engineer, 140 Nassau St., New York, N. Y..... 1901
CROES, J. J. R.
Cons. Engr., 68 Broad St., New York, N. Y..... 1882
CROLL, EMIL A.
Supt. Water-Works, Iron Mountain, Mich..... 1893
CUDDEBACK, ALLEN W.
Engr. and Supt. Passaic Water Co., 158 Ellison St., Paterson, N. J..... 1904
DAVIS, F. A. W.
Vice-Pres. and Treas. Water Co., Indianapolis, Ind.... 1886
DAVY, T. W.
Supt. Water-Works, Middletown, N. Y..... 1901

*Resigned and re-elected.

	Date of Membership.
DEERY, JOHN JEROME	
Archt. and Engr., Betz Bldg., Philadelphia, Pa.....	1901
DEFFENBAUGH, J. M.	
Water Comr., Lincoln, Neb.....	1904
DENNIS, CHARLES E.	
Supt. Water-Works, Watkins, N. Y.....	1904
DESAUSSURE, WILLIAM P.	
Vice-Pres. Vinton-Roanoke Water Co., 1103 Main St., Richmond, Va.....	1900
DEVINE, P. H.	
Superintendent of Public Works, Ishpeming, Mich.....	1903
DE YOUNG, JAMES	
Supt. Public Works, Holland, Mich.....	1905
DILL, H. A.	
Superintendent Water-Works, Richmond, Ind.....	1900
DIVEN, J. M.	
Superintendent Water-Works, Charleston, S. C.....	1884
DONAHUE, J. P	
Secretary and Treasurer Water Co., Davenport, Iowa..	1884
DOW, A. R.	
Superintendent Water-Works, Salem, Ohio.....	1902
DRUMMOND, M. J.	
President Green Island Water Supply Co., Green Island, N. Y.....	1901
DUNBAR, E. L.	
Secretary and Superintendent Water-Works, Bay City, Mich.....	1886
DUNBAUGH, GEORGE J.	
President Water Company, Pueblo, Col.....	1897
DUNHAM, H. F.,	
Consulting Engineer, 220 Broadway, New York, N. Y...	1884
DURLIN, WILLIS B.	
Water Commissioner, Erie, Pa.....	1903
EATON, HARVEY D.	
Council for Water District Trustees, Waterville, Me....	1903
EGGERS, AUGUST F.	
Water Commissioner, Newark, N. J.....	1904
ELBERT, EDWARD	
Water Commissioner, Reading, Pa.....	1904
ELLSWORTH, EMORY A.	
Civil and Hydraulic Engineer, Holyoke, Mass.....	1904
ELLWANGER, JOHN	
President Water-Works Trustees, 1392 Main St., Dubuque, Iowa.....	1903

	Date of Membership.
ELLIS, ROBERT N.	
Civil Engineer, Jacksonville, Fla	1890
ELLISON, B. F.	
General Manager Superior Water, Light and Power Co., West Superior, Wis	1893
EMERY, EZRA L.	
Supt. Green River Water-Works Co., Rock Springs, Wyo.	1897
ERICSON, JOHN	
City Engineer, Chicago, Ill	1897
EVANS, JAMES RITTENHOUSE,	
Chemist and Bacteriologist, 232 High St., Pottstown, Pa.	1905
FAIRFIELD, E. M.	
General Manager Water Co., Omaha, Neb	1902
FANNING, J. T.	
Consulting and Civil Engineer, 330 Hennipen Ave., Minneapolis, Minn	1886
FARLEY, JOHN M.	
Consulting Engineer, White Plains, N. Y	1902
FELIX, GEORGE H.	
Genl. Mgr. Water Dept., Reading, Pa	1893
FELLOWS, C. L.	
Deputy City Engineer, Toronto, Can	1904
FENN, CHAS. W., C. E.	
Mgr. Water-Works, 11 Exchange St., Portland, Me	1905
FERGUSON, W. H.	
Supt. Water-Works, Springfield, Ohio	1905
FISHER, E. A.	
City Engineer, Rochester, N. Y	1901
FITCH, W. P.	
Superintendent Water Department, Mason City, Ia	1904
FITZPATRICK, JAMES R., C. E.	
New York Continental Jewell Filtration Co., 15 Broad St., New York, N. Y	1905
FORBES, MURRAY	
Superintendent and Secretary Irwin Water Co., Greensburg, Pa	1891
FORD, EDWIN H.	
Superintendent Water-Works, Hartford City, Ind	1901
FOSTER, ERNEST H.	
Mechanical Engineer, 126 Liberty St., New York	1901
FOX, CHAS. J.	
Superintendent Water Co., Cedar Rapids, Ia	1902
FRAILEY, E. F	
Superintendent Water-Works, Lancaster, Pa	1891

	Date of Membership.
FRENCH, D. W.	
Supt. Hackensack Water Co., P. O. Box 98, Weehawken, N. J.	1895
FULLER, ALLEN J.	
General Superintendent Bureau of Water, City Hall, Philadelphia, Pa.	1901
FULLER, GEORGE W.	
Consulting Expert Water Purification, 170 Broadway, New York, N. Y.	1898
GAILEY, S. A.	
Superintendent Water Department, Altoona, Pa.	1899
GALLAGHER, JOHN F.	
Superintendent Water Works, Kingston, N. Y.	1904
GANNON, THOMAS W.	
Superintendent Water-Works, Cairo, Ill.	1904
GARDNER, L. H	
1011 Hibernia Bank Bldg., New Orleans, La.	1883
GARRISON, RALPH H.	
Superintendent of Public Works, 817 Wood St., Vineland, N. J.	1904
GATES, H. V.	
President Prineville Water & Light Co., Hillsboro, Ore.	1904
GEDNEY, JEROME D.	
Chairman Water Committtee, East Orange, N. J.	1903
GERRISH, WILLIAM BLANCHARD	
Supt. Water-Works, Oberlin, Ohio	1905
GETCHELL, WILLIAMS BASSET	
City Engineer, Augusta, Me.	1904
GICLAS, ELI	
Supt. Water-Works, Flagstaff, Arizona	1905
GLAZIER, W. L.	
Superintendent Water-Works, Newport, Ky.	1902
GLORE, W. H.	
Covington, Ky.	1890
GLOVER, ALBERT S.	
Secretary Hersey Mfg. Co., 714 Tremont Temple, Boston, Mass	1885
GRIFFIN, J. WILLIAM	
Superintendent New Jersey Suburban Water Co., Arlington, N. J.	1904
GOODELL, J. M.	
Hydraulic Engineer, Editor Engineering Record, 114 Liberty St., New York, N. Y.	1894
GOODNOW, W. T.	
General Manager Water Co., Sayre, Pa.	*1889-1903

*Resigned and re-elected.

Date of Membership.

GOODWIN, WM. G.
Superintendent and Engineer Water-Works, Kansas City, Mo. 1902

GOULD URIAH
Chief Engineer Pumping Station, Detroit, Mich..... 1903

GUBELMAN, FRED J.
Vice-Prest. O'Rourke Engineering Construction Co., 1 West 34th St., New York City, N. Y..... 1897

GUILFORD, ANDREW J.
Mechanical Engineer, The Rookery, Chicago, Ill.. ..*1889-1903

GWINN, DOW R.
President Water Co., Terre Haute, Ind..... 1893

HAGUE, C. A.
Consulting Engineer, 52 Broadway, New York, N. Y.... 1886

HALE, A. K.
Treasurer and Manager Water Co., Ann Arbor, Mich.... 1903

HALL, J. W.
Manager Water Co., Stockton, Cal..... 1904

HAMILTON, W. S.
Superintendent Water-Works, Youngstown, Ohio..... 1883

HAND, F. L.
Chief Engineer, Bureau of Water, Philadelphia, Pa.... 1901

HARBSTER, M.
Water Commissioner, Reading, Pa..... 1901

HARDY, A. W
Inspector and Hydraulic Engineer, 240 LaSalle St., Chicago, Ill..... 1904

HARLOW, GEORGE R.
Constructing Engineer, Conowingo Bridge Co., Conowingo, Md. 1884

HARLOW, JAMES H.
Consulting Engineer, 1402 Continental Trust Bldg., Baltimore, Md..... 1891

HART, ED. W.
General Manager Water Co., Council Bluffs, Ia..... 1896

HARVEY, LEE
Supt. Water Co., Conneaut, Ohio..... 1905

HATTON, T. CHALKLEY
Consulting Engineer, 608 Market St., Wilmington, Del.. 1902

HAWKS, W. E.
President and Treasurer Water-Works, Bennington, Vt.. 1892

HAZEN, ALLEN
Civil Engineer, 220 Broadway, New York, N. Y..... 1896

*Resigned and re-elected.

	Date of Membership.
HEALEY, G. B.	
President of Board of Trustees, 316 Toy Building, Sioux City, Iowa	1903
HEEGER, EMIL I.	
Member Water-Works Board, Evansville, Ind	1902
HEERMANS, H. C.	
Superintendent Water-Works Co., Corning, N. Y	1886
HEIM, J. B.	
Superintendent Water-Works, Madison, Wis	1893
HEISLER, CHARLES L.	
Mechanical Engineer, St. Marys, Ohio	1904
HELFRICH, DAVID E.	
Supt. City Water-Works, Bloomington, Ind	1905
HENDERSON, CHARLES R.	
Terre Haute, Ind	1901
HERING, RUDOLPH	
Hydraulic and Sanitary Engineer, 170 Broadway, New York, N. Y	1887
HERMANY, CHARLES	
Chief Engineer and Superintendent Water-Works, Louisville, Ky	1889
HERSCHEL, CLEMENS	
Hydraulic Engineer, 2 Wall St., New York, N. Y	1892
HIBBELER, H. D.	
Secretary and Treasurer Water Co., Washington, Mo	1904
HIGBEE, I. M.	
Superintendent Water-Works, Lewisburg, Pa	1904
HILL, JOHN W.	
Consulting Engineer, 35 and 36 Glenn Bldg., Cincinnati, Ohio	1886
HILL, NICHOLAS S., JR.	
Civil Engineer, 100 William St., New York, N. Y	1901
HILL, WILLIAM R.	
Consulting Engineer, 242 Sixth Ave., Brooklyn, N. Y	1897
HOAGLAND, IRA GOULD	
Mechanical Engineer, 19 Liberty St., New York, N. Y	1904
HOBBS, A. L.	
Superintendent and Secretary Water-Works, Raton, N. Mex.	1902
HODGKINS, H. C.	
Civil Engineer, 508 Kirk Bldg., Syracuse, N. Y	1888
HOLLINGSWORTH, ROBERT	
Chief Engr. Water Dept., Camden, N. J	1905
HOLMES, ALBA L.	
Hydraulic Engineer, 574 Wealthy Ave., Grand Rapids, Mich.	1900

	Date of Membership.
HOOPER, THOMAS N.	
Vice-President Water Co., Davenport, Ia	1884
HOPKINS, JAMES A.	
Superintendent Water-Works, Colorado Springs, Colo	1897
HORNER, CHARLES M.	
Assistant Superintendent Water-Works Co., 803 Ohio Ave., East St. Louis, Ill	1903
HORNUNG, GEORGE	
Consulting Civil and Mechanical Engineer, 612 Johnston Bldg., Cincinnati, Ohio	1887
HORTON, HORACE E.	
Civil Engineer, Chicago Bridge & Iron Co., Chicago, Ill.	1904
HOUSTON, GEORGE	
Water Commissioner, Kalamazoo, Mich	1904
HUBBELL, CLARENCE W.	
Civil Engineer Water Board, Detroit, Mich	1903
HUGGINS, D. E.	
Manager Water-Works, Streator, Ill	1896
HULLEY, ELKANAH	
Superintendent Water-Works, Marion, Ind	1898
HUMPHREYS, WILLIAM HENRY	
Engineer, Manager and Secretary Water-Works Co., Lendal Bridge, York, England	1904
HUNTER, W. J.	
Manager Charters Valley Water Co., 235 Orchard St., Knoxville, Pittsburg, Pa	1903
HUTTON, GEORGE J.	
Water Commissioner, Harrisburg, Pa	1904
HUTZEL, TITUS F.	
Superintendent Water Co., Ann Arbor, Mich	1903
JACKSON, ROBERT A.	
Superintendent Insurance & Water Co., Norristown, Pa.	1903
JEFFERIS, LOUIS M.	
Constructing Engineer, 623 Vennica Ave., East St. Louis, Ill	1904
JONES, A. J.	
P. O. Box 273, New Brunswick, N. J	1884
JONES, GEORGE L.	
Engineer Water Works, Lorain, O	1901
JONES, R. HENRY	
Supt. Water Works, Norfolk, Va.	1901
KASTBERG, KARL C.	
City Engr. and Supt. City Water-Works, Boone, Ia	1904

	Date of Membership.
KEELER, H. E. Pres. Rogers Park Water Co., 97 South Clinton St., Chicago, Ill.	1887
KELLEY, JOHN C. Director Water-Works, 84-86 Chambers St., New York, N. Y.	1890
KELLEY, NICHOLAS J. Supt. Depew and Lake Erie Water Co., 1361 Abbott Road, Buffalo, N. Y.	1903
KELLOGG, R. M. Supt. Middlesex Water Co., Metuchen, N. J.	1901
KEMP, JOHN EDWARD Supt. Water Department, Kewanee, Ill.	1904
KENNEDY, GEORGE G. Supt. Water-Works, Harrisburg, Pa.	1904
KIMBALL, FRANK C. 14 Beacon St., Boston, Mass.	1902
KING, ADOLPHE J. Genl. Mgr. Water-Works, Alamogordo, New Mex.	1904
KINGSLEY, MARVIN W. Civil Engr., Rose Bldg., Cleveland, Ohio.	1899
KNOX, H. E., Jr. Hydraulic Engineer, Piedmont Bldg., Charlotte, N. C.	1901
KNOX, W. F. Sec. Water Company, Tyler, Tex.	1896
KNUDSON, A. A. Electrical Engr., 34 Nassau St., New York, N. Y.	1900
KOENIG, ARNOLD C. Sec. Board of Water Commissioners, 514 Bee Building, Omaha, Neb.	1901
KUHN, W. S. Genl. Mgr. American Water-Works and Guarantee Co., P. O. Box 1103, Pittsburg, Pa.	1886
KUHN, JACOB Water-Works Contractor, York, Pa.	1891
KUICHLING, E. Civil Engr., 52 Broadway, New York, N. Y.	1896
LAING, H. H. Supt. Water-Works, Racine, Wis.	1902
LANDES, J. D. Sec. and Treas. Canajoharie, N. Y., Water Supply Co., Mechanicsburg, Pa.	1904
LAUTZ, HENRY Supt. Pekin Water-Works Co., Pekin, Ill.	1896

Date of Membership.

LeConte, L. J.
Civil and Con. Engr., P. O. Box 482, Oakland, Cal..... 1886
Leisen, Theodore Alfred
Chief Engr. Water Dept., Wilmington, Del..... 1904
Lefavor, Walter L.
Mgr. Water Co., Springfield, Mo..... 1904
Levey, Ernest C., M. D.
Bacteriologist and Director of Laboratory of City Water Dept., Richmond, Va..... 1905
Little, Beekman C.
Supt. Water-Works, 44 City Hall, Rochester, N. Y.... 1903
Locke, J. W.
Assistant Supt. Water-Works, Brockton, Mass..... 1896
Lockwood, Charles A.
Pres. Jamaica Water Supply Co., Jamaica, L. I., N. Y.... 1903
Longyear, O. C.
79 Maiden Lane, Kingston, N. Y..... 1898
Lord, Harry A.
Supt. Water-Works, Ogdensburg, N. Y..... 1903
Lorenz, John
Electric Light & Power Co., Jackson, Miss..... 1902
Lovell, Walter D.
Con. Engr., 602 Equitable Bldg., Des Moines, Ia..... 1898
Lucas, Fred L.
Mgr. and Sec. Light and Water Co., Pontiac, Ill..... 1903
Ludlow, J. L.
Con. Engr., Winston-Salem, N. C..... 1904
Lyon, Henry L.
Deputy Water Commissioner, Buffalo, N. Y..... 1903
McAlpine, A. H.
Genl. Western Agent Hersey Mfg. Co., 426 N. High St., Columbus, Ohio 1889
McArthur, Arthur
Supt. Water-Works, Dubuque, Iowa..... 1902
McCabe, H. Dallas
Supt. Water Co., Monessen, Pa..... 1905
McCarthy, Danl. B.
Supt. Water-Works, Waterford, N. Y..... 1905
McConnell, J. H.
Supervisor Water Department, Minneapolis, Minn..... 1901
McConnell, W. C.
Pres. Water Company, Shamokin, Pa..... 1888
McCorkindale, Wm. J.
Mgr. Gas, Light and Fuel Co. Sherman, Tex..... 1903

	Date of Membership.
McCormick, W. T.	
Water-Works Contractor, Charlotte, N. C.	1896
McCue, W. F.	
Care The Colorado Fuel and Iron Co., Boston Building, Denver, Col.	1897
MacDermot, L. C.	
Supt. Water Department, 26 South Walnut St., East Orange, N. J.	1903
MacDonald, Emmett	
Supt. Water and Light Co., Lincoln, Ill.	1904
McGrath, Robert H.	
Water-Works Trustee, LaFayette, Ind.	1904
McGilvray, Thomas T.	
City Engr., Duluth, Minn.	1903
McKim, Robert Albert	
Asst. Engr. New Croton Aqueduct, 34 W. 91st St., New York, N. Y.	1902
McLeod, T. T.	
Mgr. Water Co., Missoula, Mont.	1904
McNamee, T. W.	
Supt. Water Company, Wabash, Ind.	1903
McWilliams, C. Q.	
Pres. Roaring Creek Water Co., P. O. Box 85, Shamokin, Pa.	1901
Maignen, P. A.	
Water Engineer, 52 N. 13th St., Philadelphia, Pa.	1900
Manley, Samuel C.	
Pres. and Genl. Mgr, Maine Water Co., Augusta, Me.	1903
Manville, F. D.	
Local Mgr. Newport News Light & Water Co., Newport News, Va.	1901
Marple, Wm. M.	
Chief Engr. Gas and Water Co., Scranton, Pa.	1905
Martin, H. P.	
Supt. Water-Works, Owensboro, Ky.	1888
Mason, W. P., Dr.	
Prof. Chemistry, Rensselaer Poly. Institute, Troy, N. Y.	1892
Mather, Edmund	
Pres. Water Board, Harrisburg, Pa.	1891
Maury, Dabney H.	
Consulting Engr. Peoria Water-Works Co., 129 North Jefferson Ave., Peoria, Ill.	1894
Mead, Daniel W.	
Con. Engr. First National Bank Building, Chicago, Ill.	1889

Date of Membership.

MELLON, T. A.
Pres. Kensington Water Co., 514 Smithfield St., Pittsburg, Pa. 1903
METCALF, LEONARD
Con. Civil Engr., 14 Beacon St., Boston, Mass..... 1903
MEYER, A. N.
Water Registrar, Milwaukee, Wis..... 1905
MEYERS, A. H.
Supt. Water Co., Columbia, Pa..... 1903
MICHIE, JOHN C.
Civil Engr., Supt. Water Co., Durham, N. C..... 1903
MILLER, J. A.
Supt. Water Co., Louisiana, Mo..... 1904
MILLER, JOSEPH TORRENCE
Sec. and Treas. Pennsylvania Water Co., 424 Maple Ave., Edgewood, Pittsburg, Pa..... 1903
MILLIGAN, R. E.
Chemist, 15 Broad St., New York, N. Y..... 1902
MILNE, ALEXANDER
Supt. Water-Works, St. Catharines, Ontario, Can..... 1903
MILNER, W. J.,
Care of Tutwiller Coal and Coke Co., New Orleans, La.. 1884
MILTON, RICHARD H.
Supt. Water-Works, Reidsville, N. C..... 1902
MOLIS, WM.
Supt. Water-Works, Muscatine, Iowa..... 1882
MONJEAU, C.
Hydraulic Engr., Middletown, Ohio..... 1889
MOTH, R. H.
City Engr. and Supt. Water-Works, Kenosha, Wis.... 1901
MYERS, GEO. M.
Pres. Water & Light Co., 505 New England Bldg., Kansas City, Mo..... 1902
MULHALL, JNO. F. J.
Public Accountant, 62 Astoria St., Boston, Mass..... 1905
NETTLETON, CHARLES H.
Agent Birmingham Water Co., Derby, Conn..... 1888
NUEBLING, EMIL L.
Supt. and Engr. Water Department, Reading, Pa..... 1895
NEVILLE, THOMAS J.
Comr. Public Works, Rochester, N. Y..... 1888
NEWTON, HOWARD D.
Pres. Water-Works Co., 175 Broad St., Norwich, N. Y.. 1903
NOURSE, H. O.
Supt. Bureau of Water, Chicago, Ill..... 1903

	Date of Membership.
OHLIGER, L. B.	
Supt. Water-Works, Canton, Ohio	1899
OMBERG, JAMES A.	
City Engr., Memphis, Tenn	1905
O'SHAUGHNESSY, JERRY	
Supt. Department of Water, Columbus, Ohio	1897
PARKIN, R. R.	
Supt. Water-Works, Elgin, Ill	1890
PATERSON, ARTHUR C.	
Supt. Water-Works, Everett, Wash	1901
PATTON, W. A.	
Pres. and Mgr. Catlettsburg, Kenora & Ceredo Water Co., Catlettsburg, Ky	1904
PAYSON, EDGAR R.	
Treas. and Supt. Water Co., 33 Plum St., Portland, Me	1905
PEASE, WALTER D.	
City Engr. and Water Commissioner, P. O. Box 218, Cheyenne, Wyo.	1905
PEENE, EDWARD L.	
Supt. Water-Works, Yonkers, N. Y	1901
PENNEY, C. L.	
Edgewood Park, Pa	1902
PERRY, WILLIAM	
Hydraulic Engr., 234 Craig St., West, Montreal, Can	*1886-1903
PRENTER, MARTIN	
Sec. and Genl. Mgr. Monongahela Water Co., 1113 Carson St., Pittsburg, Pa	1903
PRENTICE, ALLEN T.	
Mechanical Engr., 499 N. State St., Chicago, Ill	1890
PHILIPS, T. C.	
Water-Works Engr., 287 East 41st St., Chicago, Ill	1905
PITCHER, F. H.	
Genl. Mgr. and Chief Engr. Montreal Water and Power Co., 62 Alliance Bldg., Montreal, Can	1905
PITT, B. R.	
Pres. Water-Works Company, Pensacola, Fla	1896
POETSCH, CHARLES J.	
City Engr. and Pres. Board of Public Works, Milwaukee, Wis.	1903
POLLARD, W. D.	
Engr. Water-Works, Pottsville, Pa	1892
POWERS, J. B.	
Trustee and Sec. Board of Water-Works Trustees, 312 Security Bldg., Dubuque, Iowa	1903

*Resigned and re-elected.

Date of Membership.

PRIDDY, CHAS. N.
Sec. and Supt. Water-Works, Leadville, Col..... 1886

PUGH, MARSHALL R.
Civil Engr., 1334-5 Real Estate Trust Bldg., Philadelphia, Pa. 1905

PURDY, J. H.
Supt. American Water-Works and Guarantee Company, P. O. Box 1103, Pittsburg, Pa..... 1896

QUICK, ALFRED MERRITT
Water Engr., Baltimore, Md..... 1901

RANDOLPH, W. C. N., JR.
Supt. Water-Works, Lynchburg, Va..... 1902

RAPP, W. M.
Supt. Construction Water Department, Atlanta, Ga.... 1899

REED, WILBUR F.
Supt. Water-Works, Kalamazoo, Mich..... 1901

REYER, GEO.
1004 South College St., Nashville, Tenn..... 1884

RILEY, LEE
Chief Engr. Metropolitan Water Co., Kansas City, Kan. 1897

ROBERTSON, GEO. H.
Supt. Water-Works, Yarmouth, N. S..... 1888

ROBERTSON, WM. F.
Supt. Clarendon Water Co., Wilmington, N. C..... 1903

ROBINSON, WM. P.
Mgr. Denver Union Water Co., Denver, Col..... 1897

ROBINSON, SIDNEY C.
Mgr. Water-Works, Walkerville, Ontario, Can..... 1904

ROBLIN, FRED. B.
Mgr. Water and Electric Co., Kalispell, Mont..... 1905

ROLFE, W. E.
Engr. of Distribution Water Dept., 3855 Flad Ave., St. Louis, Mo. 1904

ROSAMOND, S. J.
Supt. Municipal Water-Works Company, Fort Smith, Ark. 1898

ROWE, CHARLES E.
Supt. Dept. of Water, Dayton, Ohio..... 1901

RUSSELL, W. S.
Dickson, N. D..... 1895

RUST, C. H.
City Engr. and Mgr. Water-Works, Toronto, Can..... 1903

RUTHRAUFF, HARRY
Water and Plumbing Inspector, Decatur, Ill.....*1898-1903

	Date of Membership.
RYDER, PHILIP F.	
Vice-Pres. and Treas. Water-Works Trustees, Dubuque, Iowa	1903
RYLE, WILLIAM	
Paterson, N. J.	1884
SALMON, C. B.	
Owner Water-Works, Beloit, Wis.	1902
SANDO, WILL J.	
Water-Works Commercial Consulting Engr., care of Allis-Chalmers Co., Milwaukee, Wis.	1905
SANZENBACHER, GEORGE	
Asst. Engr. and Supt. Dept. of Water Newark, N. J.	1905
SAWYER, J. T.	
Pres. Water-Works Co., Waverly, N. Y.	1885
SCOTT, WILLIAM G.	
City Treas. and Mgr. Financial Dept. Water-Works, Winnipeg, Manitoba, Canada	1903
SHAW, HORACE H.	
Mgr. Municipal Water-Works Co., Portland, Me.	1905
SHEPHERD, A. B.	
Supt. of Water Supply and Distribution, Pittsburg, Pa.	1896
SHEPPARD, JAMES H.	
Supt. City Water Co., Monongahela, Pa.	1903
SHEPPERD, F. W.	
Fire and Water Engineering, Bennett Bldg., New York, N. Y.	1888
SHERRERD, MORRIS R.	
Chief Engineer Street and Water Commission, 128 Halsey St., Newark, N. J.	1897
SHIELDS, W. S.	
Con. Engr., 1715 Marquette Building, Chicago, Ill.	1899
SIDELINGER, GEO. B.	
Supt. Water-Works, Danville, Ill.	1902
SIMIN, NICHOLAS P.	
Con. Engr., 3 Razgulay, Moscow, Russia.	1898
SIMPSON, LAWRENCE	
Sec. Water Company, Memphis, Tenn.	1898
SLOCUM, CHARLES EGBERT	
Supt. Belleville Deep Well Water Co., Belleville, Ill.	1902
SMITH, ANTHONY P.	
Mechanical Engr., Newark, N. J.	1890
SMITH, ERASTUS G., Ph. D.	
Professor Chemistry, Beloit, Wis.	1890
SMITH, H. L.	
Norfolk, Va.	1903

Date of Membership.

SMITH, J. WALDO
Chief Engr., Commission of Additional Water Supply for New York City, 299 Broadway, New York 1898

SMITH, OWEN T.
Supt. Water-Works, Freeport, Ill..... 1893

SOPER, GEO. A., PH. D.
Engr. and Chemist, 29 Broadway, New York, N. Y..... 1900

SNOW, F. H.
Con. Engr., 1120 Tremont Bldg., Boston, Mass..... 1899

SNOW, ARCHIE H.
Supt. Water Company, Montclair, N. J..... 1898

SPALDING, E. B.
Supt. Water-Works, Sioux City, Iowa..... 1899

SPRENKEL, JOHN F.
Genl. Mgr. York Water Co., York, Pa..... 1901

STERLING, JOE C.
Supt Water-Works, Monroe, Mich..... 1903

STRASSER, J. M.
Supt. Electric Light & Power Co., LaGrange, Ill..... 1896

STRAUSE, NATHAN
Pres. Water-Works, Ashland, Ohio..... 1904

TALBOT, ARTHUR N.
Professor of Municipal and Sanitary Engineering, University of Illinois, Urbana, Ill..... 1894

TALBOTT, FRANK
Supt., Sec. and Treas. Water-Works, Danville, Va..... 1904

TAUBENHEIM, ULRICH E.
Mgr. Water-Works, Archangel, Russia..... 1905

TAYLOR, SAMUEL A.
Con. and Constructing Engr., 900 Lewis Block, Pittsburg, Pa. 1902

THOMAS, C. O.
Pres. Water Co.,Caro, Mich..... 1903

THOMAS, ROBT. J.
Supt. Water-Works, Lowell, Mass..... 1900

TIGHE, JAMES L.
City Engr., Holyoke, Mass..... 1901

TILDEN, JAS. A.
Mechanical Engr., Hersey Mfg. Co., Boston, Mass..... 1889

TOAL, D. C.
Editor "Water and Gas Review," 35 Warren St., New York, N. Y..... 1903

TODD, WILLIAM
Supt. Electric Light & Water-Works, Austin, Minn.... 1901

	Date of Membership.
TOMLINSON, SAMUEL	
Department Ex-Engineer Water-Works, Municipal Engineer, Raffles Place, Singapore, S. S.	1887
TORRENCE, KENNETH	
Chief Engineer Pumping Station, Logan St. and Atlantic Ave., Brooklyn, N. Y.	1897
TRAUTWINE, JNO. C., JR.	
Civil Engineer, 257 South Fourth St., Philadelphia, Pa.	1896
TRAVIS, ISAAC N.	
Supt. Water-Works, Orange, N. J.	1898
TUBBS, J. NELSON	
Con. Engr. 405 Wilder Bldg., Rochester, N. Y.	1886
TUCKER, A. A.	
Supt. Mains, Water Dept., Memphis, Tenn.	1892
VAN DUYNE, J. RALPH	
Asst. Engr. Dept. of Water, Newark, N. J.	1905
VEACH, W. A.	
Manager Water-Works Company, Newark, Ohio.	1896
VERNER, T. H.	
Supt. Water and Light Dept., McKeesport, Pa.	1903
VOLKHARDT, WILLIAM	
Stapleton, N. Y.	1902
WALL, E. E.	
Asst. Water Comr., 4220 McPherson St., St Louis, Mo.	1904
WANNER, P. D.	
Pres. Newport Home Water Co., Reading, Pa.	1891
WARDE, JOHN S.	
Supt. and Engr. Staten Island Water Supply Company, West New Brighton, N. Y.	1892
WATKINS, THOMAS	
Mechanical Engr., Johnstown, Pa.	1892
WATSON, WALTER L.	
Supt. Clear Spring Water Co., Catasaqua, Pa.	1901
WATTS, W. H.	
Supt. Water-Works, El Paso, Tex.	1888
WAY, J. F.	
Supt. Water, Light & Power Co., Watertown, S. Dak.	1904
WHEELER, SAM	
Supt. Water Co., Ashland, Wis.	1903
WHEELER, GENL. ELBERT	
Treas. Knoxville, Tenn., Water Co., 14 Beacon St., Boston, Mass.	1903
WEGMAN, EDWARD	
Care Aqueduct Commission, 5 Court St., White Plains, N. Y.	1902

	Date of Membership.
WEHR, ALBERT H. Sec. and Treas. Baltimore County Water & Electric Company, Baltimore, Md	1901
WELLING, ROBERT Supt. Water-Works, Covington, Ky	1905
WESTON, ROBERT SPURR Chemist and Bacteriologist, 14 Beacon St., Boston, Mass.	1898
WHIPPLE, GEORGE C. Con. Engr., 220 Broadway, New York, N. Y	1904
WHITNEY, DR. GEO. F. Biologist, 44 Central Ave., East Orange, N. J	1904
WILES, C. W. Supt., Sec. and Treas., Water-Works, Delaware, Ohio	1899
WILKINSON, J. H. Supt. Water-Works, Bowling Green, Ky	1889
WILLIAMS, HOWARD L. Supt. Water-Works, Luddington, Mich	*1894-1903
WILLS, E. S. Supt. Water Company, Atchison, Kan	1885
WINGFIELD, NISBET Consulting Engr., Augusta, Ga	1905
WIRT, R. D. 219 North Third St., Philadelphia, Pa	1885
WITMER, J. F. Hydraulic and Sanitary Engineer, Chapin Block, Buffalo N. Y.	1905
WOOD, JAS. W. Pres. Henderson Water Company, Henderson, N. C., care Tippett & Wood, Phillipsburg, N. J	1896
WOOD, JOHN H. Sec. and Supt. Water-Works, Baton Rouge, La	1893
WOOD, WALTER Pres. Millville, N. J., Water Co., 400 Chestnut St., Philadelphia, Pa	1905
WOODBURN, WM. F. Director Water Co., 10 Chestnut St., Springfield, Mass	1903
WOODRUFF, TIMOTHY Supt. Water-Works, Bridgeton, N. J	1888
WOODWARD, PARK Genl. Mgr. Water-Works, Atlanta, Ga	1896

*Resigned and re-elected.

	Date of Membership.
WORRELL, M. L.	
Secy. and Treas. Water Company, Selma, Ala.....	1903
WYNNE-ROBERTS, R. O.	
M. Inst. C. E., F. R. San. Inst. Water Engineer, Capetown, South Africa.....	1903
WRIGHT, MILLARD F.	
Supt. Water-Works, Butler, Pa.....	1890
YOUNG, EZRA P.	
Pres. Water Company, Edgeworth, Pa.....	1902

ASSOCIATE MEMBERS.

	Date of Membership.
ADAMS, LYDON E.	
Gen.. Sales Mgr. Garlock Packing Co., 5224 Parkside, Philadelphia, Pa.	1904
ALLIS-CHALMERS CO.	
Milwaukee, Wis.	1905
AMERICAN ASPHALTUM AND RUBBER CO.	
Woman's Temple, Chicago, Ill.	1903
AMERICAN PIPE MANUFACTURING CO., THE	
112 North Broad St., Philadelphia, Pa.	1903
AMERICAN STEEL AND WIRE CO.	
The Rookery, Chicago, Ill.	1903
AMERICAN VALVE AND METER CO.	
324 Pike Bldg., Cincinnati, Ohio.	1900
BABCOCK & WILCOX BOILER CO.	
85 Liberty St., New York, N. Y.	1806
BINGHAM & TAYLOR	
Church and Jackson Sts., Buffalo, N. Y.	1882
BOURBON COPPER AND BRASS WORKS CO.	
618 East Front St., Cincinnati, Ohio.	1889
BUFFALO METER CO.	
290 Terrace, Buffalo, N. Y.	1905
BUILDERS IRON FOUNDRY	
9 Codding St., Providence, R. I.	1901
CAMPBELL, J. B., BRASS WORKS	
Brass and Iron Goods for Water-Works, Erie, Pa.	1901
CENTRAL FOUNDRY CO.	
116 Nassau St., New York, N. Y.	1903
CHAPMAN VALVE MANUFACTURING COMPANY	
Indian Orchard, Mass.	1884
CHICAGO BRIDGE AND IRON COMPANY	
Builders of Water Towers and Standpipes, 1402, 105th cor. Throop Sts., Chicago, Ill.	1898
CLOW, J. B. & SONS	
Harrison and Franklin Sts., Chicago, Ill.	1885
COLORADO FUEL AND IRON COMPANY	
Denver, Col.	1897
COLUMBUS BOARD OF PUBLIC SERVICE	
Water Dept., Columbus, Ohio.	1887
COLUMBUS METER SEAL MFG. CO., THE	
The Hayden Bldg., 136 E. Main St., Columbus, Ohio.	1904
COOK WELL COMPANY	
15 S. Fourth St., St. Louis, Mo.	1894

	Date of Membership.
DAY, CHARLES R.	
Sales Agent The Midvale Steel Co., 111 Broadway, New York, N. Y.	1904
DAYTON BOARD OF PUBLIC SERVICE	
Water Dept., Dayton, Ohio	1892
DETROIT CHEMICAL WORKS	
190-260 Junction Ave., Detroit, Mich	1903
DRESSER, S. R.	
Mfgr. Pipe Couplings and Sleeves, Bradford, Pa	1904
DRUMMOND, M. J. & CO.	
Cast Iron Pipe, 182 Broadway, New York, N. Y	1895
EDDY VALVE MANUFACTURING CO.	
Waterford, N. Y	1886
ELEY, PHILIP	
Machine Water Appliances, Bayonne, N. J	*1892-1901
ELLIS-FORD PIPE CUTTER CO.	
P. O. Box 59, Detroit, Mich	1905
FAIRBANKS COMPANY, THE	
Broome and Elm Sts., New York, N. Y	1905
FARNAN BRASS WORKS	
23 Centre St., Cleveland, Ohio	1892
GAMEWELL FIRE ALARM TELEGRAPH CO., THE	
19 Barclay St., New York, N. Y	1903
GENERAL CHEMICAL CO.	
Manufacturers of Filter Alum and Dealers in Sulphur, 135 Adams St., Chicago, Ill	1902
GENERAL FIRE EXTINGUISHER COMPANY	
Executive Offices, Union Trust Bldg., Providence, R. I	1905
GILLESPIE, T. A.	
Pres. The T. A. Gillespie Co., 71 Broadway, New York, N. Y	1904
GLAUBER BRASS MFG. CO.	
1643-1677 Superior St., Cleveland, Ohio	1904
GREAT FALLS, MONTANA, WATER DEPARTMENT	
Great Falls, Mont	1904
HAYS MANUFACTURING COMPANY	
Erie, Pa	1882
HERSEY MANUFACTURING COMPANY	
South Boston, Mass	1887
HOGE & SWIFT	
Manufacturers' Agents, Portland, Oregon	1904
ILLINOIS MALLEABLE IRON COMPANY	
30 W. Monroe St., Chicago, Ill	1890

*Resigned and re-elected.

	Date of Membership.
INTERNATIONAL STEAM PUMP CO.	
Water-Works Machinery, 114 Liberty St., New York, N. Y.	1901
JACKSON FILTER MFG., CO.	
Chemical Building, St. Louis, Mo.	1904
KELLOGG, E. H. & CO.	
243 South St., New York, N. Y.	1886
KENNEDY, DANIEL.	
Pres. Kennedy Valve Manufacturing Company, 57 Beekman St., New York, N. Y.	1895
LEAD LINED IRON PIPE CO., THE	
Wakefield, Mass.	1898
LENNOX MACHINE COMPANY	
Water Tapping Machine, Marshalltown, Iowa.	1896
LONDON WATER BOARD	
London, Canada	1892
LUDLOW VALVE MANUFACTURING COMPANY	
Troy, N. Y.	1882
MODERN IRON WORKS	
Quincy, Ill.	1905
MUELLER, H., MANUFACTURING COMPANY	
Decatur, Ill.	1882
NATIONAL BRASS & METAL CO.	
256 S. Third St., Minneapolis, Minn.	1904
NATIONAL METER COMPANY	
84-86 Chambers St., New York, N. Y.	1882
NEPTUNE METER CO.	
120 Liberty st., New York, N. Y.	1894
NEW YORK CONTINENTAL JEWELL FILTRATION CO.	
15 Broad St., New York, N. Y.	1888
NORFOLK WATER-WORKS	
Norfolk, Va.	1889
PENNSYLVANIA SALT MANUFACTURING CO., THE	
115 Chestnut St., Philadelphia, Pa.	1903
PITTSBURG FILTER MANUFACTURING CO.	
Farmers Bank Bldg., Pittsburg, Pa.	1905
PRESIDENT BOARD OF PUBLIC WORKS	
Grand Rapids, Mich.	1895
PLATT IRON WORKS CO.	
Pumping Engines, Dayton, Ohio	1901
PLEUGER & HENGER MANUFACTURING COMPANY	
St. Louis, Mo.	1896
PITTSBURG METER COMPANY	
East Pittsburg, Pa.	1898
RENSSELAER MANUFACTURING COMPANY	
Troy, N. Y.	1890

	Date of Membership.
Ross Valve Co.	
Oakwood Ave., Troy, N. Y.	1891
Ryerson & Son, Joseph T.	
Iron and Steel Merchants and Special Agents, 18 Milwaukee Ave., Chicago, Ill.	1902
Safety Meter Lock Co.	
M. A. Corbet, Mgr., Columbus, Ohio	1905
Smith, Anthony P., Manufacturing Co.	
Newark, N. J.	1897
Sweet & Doyle Valve Co.	
Manufacturers Water Valves, Cohoes, N. Y.	1900
Thomson Meter Company	
79 Washington St., Brooklyn, N. Y.	1891
Tod, The William Co.	
High Duty Pumping Engines, Youngstown, Ohio	1904
Trenton Water Works	
Trenton, N. J.	1898
Union Water Meter Company	
Worcester, Mass.	1882
United States Cast Iron Pipe and Foundry Company	
217 La Salle St., Chicago, Ill.	1902
Walworth Manufacturing Company	
132 Federal St., Boston, Mass.	1891
Westinghouse Machine Co., The	
East Pittsburg, Pa.	1904
Whitall, W. van R.	
Pres. Hydro-Carbon Co., 320 Wazee St., Denver Colo.	1904
Wood, R. D. & Co.	
400 Chestnut St., Philadelphia, Pa.	1884
Yeiser, L. B.	
Salesman for The Sanitary Co., Cleveland, Ohio	1904

SUMMARY.

Honorary Members	7
Active Members	411
Associate Members	77
Total	495

LIST OF MEMBERS ARRANGED GEOGRAPHICALLY

ALABAMA.—Total Membership, 2.

HONORARY.

Cameron, W. L.

ACTIVE.

Worrell, M. L.

ARIZONA.—Total Membership, 1.

ACTIVE.

Giclas, Eli

ARKANSAS.—Total Membership, 1.

ACTIVE.

Rosamond, S. J.

CALIFORNIA.—Total Membership, 4.

ACTIVE.

Booker, Geo. E. Hall, J. W. LeConte, L. J.
Charles, S. A.

COLORADO.—Total Membership, 8.

ACTIVE.

Case, E. W. Dunbaugh, Geo. J. Hopkins, Jas. J.
McCue, W. F. Priddy, Chas. N. Robinson, Wm. P.

ASSOCIATE.

Colorado Fuel & Iron Co. Whitall, W. Van R.

CONNECTICUT.—Total Membership, 2.

ACTIVE.

Brooks, Isaac V. Nettleton, Chas. E.

DELAWARE.—Total Membership, 3.

ACTIVE.

Bond, Jas. A. Hatton, T. Chalkley Leisen, Theodore A.

FLORIDA.—Total Membership, 2.

ACTIVE.

Ellis, Robt. N. Pitt, B. R.

GEORGIA.—Total Membership, 4.

ACTIVE.

Clayton, R. M. Rapp, W. M. Wingfield, Nisbet
Woodward, Park

ILLINOIS.—Total Membership, 45.

HONORARY.

Foster, J. F.

ACTIVE.

Alvord, John W.
Amsbary, F. C.
Artingstall, Sam'l G.
Bancroft, P. T.
Burns, T. W.
Clark, H. W.
Cobb, Chas. H.
Cole, Jno. A.
Ericson, John
Gannon, Thos. W.
Guilford, Andrew J.
Hardy, A. W.
Horner, Chas. M.
Horton, Horace E.
Huggins, D. E.
Jeffries, Louis M.
Keeler, H. E.
Kemp, John Edward
Lautz, Henry
Lucas, Fred L.
McDonald, Emmett
Maury, Dabney H.
Mead, Dan'l. W.
Nourse, H. O.
Parkin R. R.
Philips, T. C.
Prentice, Allen T.
Ruthrauff, Harry
Shields W. S.
Sidelinger, Geo. B.
Slocum, Chas. Egbert
Smith, Owen T.
Strasser, J. M.
Talbot, Arthur N.

ASSOCIATE.

American Asphaltum & Rubber Company
American Steel & Wire Company
Chicago Bridge & Iron Company
Clow, J. B. & Son
General Chemical Co.
Illinois Malleable Iron Company
Modern Iron Works
Mueller, H. Mfg. Co.
United States Cast Iron Pipe & Fdy. Co.
Ryerson, Jos. T. & Son

INDIANA.—Total Membership, 11.

ACTIVE.

Brown, Chas. Carroll
Davis, F. A. W.
Dill, H. A.
Ford, Edwin H.
Gwinn, Dow R.
eeger, Emil I.
Helfrich, David E.
Hulley, Elkanah
McGrath, Robert H.
Henderson, C. R.
McNamee, T. W.

IOWA.—Total Membership, 18.

ACTIVE.

Barker, W. H.
Berry, J. P.
Chatham, J.
Donahue, J. P.
Ellwanger, John
Fitch, W. P.
Fox, Chas. J.
Hart, Edward W.
Healey, G. B.
Hooper, Thos. N.
Kastberg, Karl C.
Lovell, Walter L
McArthur, Arthur
Molis, William
Powers, J. B.
Ryder, Philip F.
Spalding, E. B.

ASSOCIATE.

Lennox Machine Co.

KANSAS.—Total Membership, 5.

ACTIVE.

Bishop, John L.
Chisham, J. M.
Hood, Charles
Riley, Lee
Wills, E. S.

KENTUCKY.—Total Membership, 8.

ACTIVE.

Burnett, M.		Glazier, W. L.
Glore, W. H.	Hermany, Charles	Martin, H. P.
Patton, W. A.	Wilkinston, J. H.	Welling, Robert

LOUISIANA.—Total Membership, 3.

ACTIVE.

Gardner, L. H.	Milner, W. J.	Wood, John H.

MAINE.—Total Membership, 6.

ACTIVE.

Eaton, Harvey D.	Fenn, Chas. W.	Getchell, Wm. Bassett
Manley, Sam'l. G.	Payson, Edgar R.	Shaw, Horace H.

MARYLAND.—Total Membership, 3.

ACTIVE.

Harlow, James R.	Quick, Alfred Merritt	Wehr, Albert H.

MASSACHUSETTS.—Total Membership, 19.

ACTIVE.

Bancroft, Lewis	Cook, Henry A.	Ellsworth, Emory A..
Glover, Albert S.	Kimball, Frank C.	Locke, J. W.
Metcalf, Leonard	Mulhall, John F. J.	Snow, F. H.
Thomas, Robert J.	Tighe, James L.	Tilden, James A.
Wheeler, Gen'l. Elbert	Weston, Robert Spurr	

ASSOCIATE.

Chapman Valve Mfg. Co.	Hersey Mfg. Co.	Lead Lined Pipe Mfg. Co.
Union Water Meter Co.	Walworth Mfg. Co.	

MICHIGAN.—Total Membership, 22.

ACTIVE.

Anderson, L. W.	Cahill, Stephen	Campbell, Jas. J.
Carroll, Dan'l. W.	Croll, Emil A.	Devine, P. H.
DeYoung, James	Dunbar, E. L.	Gould, Uriah
Hale, A. E.	Holmes, Alba L.	Houston, George
Hubbell, Clarence W.	Hutzel, Titus F.	Reed, Wilbur F.
Sterling, Jos. C.	Thomas, C. O.	Williams, Howard L.
Wing, Abram		

ASSOCIATE.

Detroit Chemical Works	Grand Rapids Water-Works	Ellis-Ford Pipe Cutter Co.

MINNESOTA.—Total Membership, 10.

HONORARY.

Bement, R. B. C.

ACTIVE.

Cappelen, F. W.	Case, L. N.	Caulfield, John
Connor, F. J.	Fanning, J. T.	McConnell, J. H.
McGilvray, Thos. T.	Todd, William	

ASSOCIATE.

National Brass & Metal Co.

MISSISSIPPI.—Total Membership, 1.

ACTIVE.

Lorenz, John

MISSOURI.—Total Membership, 17.

HONORARY.

Holman, M. L.	Watts, Sylvester

ACTIVE.

Adkins, B. C.	Anderson, J. F.	Andrews, Lewis
Binder, Frederic C.	Brown, L. O.	Goodwin, Wm. G.
Hibbeler, H. D.	Lefavor, Walter L.	Miller, J. A.
Myers, Geo. M.	Rolfe, W. E.	Wall, E. E.

ASSOCIATE.

Cook Well Co.	Jackson Filter Mfg. Co.	Pleuger & Henger Mfg. Co.

MONTANA.—Total Membership, 4.

ACTIVE.

Carroll, Eugene	McLeod, T. T.	Roblin, Fred. B.

ASSOCIATE.

Great Falls Water Dept.

NEBRASKA.—Total Membership, 4.

ACTIVE.

Carlson, J. A.	Deffenbaugh, J. M.	Fairfield, E. M.
Koenig, Arnold D.		

NEW JERSEY.—Total Membership, 27.

ACTIVE.

Bauman, C. V.	Burleigh, John J.	Conard, W. R.
Corr, Andrew S.	Cuddeback, Allen W.	Eggers, August F.
French, D. W.	Garrison, Ralph H.	Gedney, Jerome D.
Griffin, J. Wm.	Hollingsworth, Robt.	Jones, A. J.
Kellogg, R. M.	McDermot, L. C.	Ryle, William
Sanzenbacher, George	Sherrerd, Morris R.	Smith, Anthony P.
Snow, Archie H.	Travis, Isaac N.	Van Duyne, J. Ralph
Whitney, Dr. Geo. F.	Wood, James W.	Woodruff, Timothy

ASSOCIATE.

Eley, Philip	Smith, Anthony P., Mfg. Co.	Trenton Water Works

NEW MEXICO.—Total Membership, 2.

ACTIVE.

Hobbs, A. L.
King, Adolphe J.

NEW YORK.—Total Membership, 87.

HONORARY.

Holly, Ira A.

ACTIVE.

Anderson, John
Baker, M. N.
Bettes, Chas. S.
Bogart, John
Cole, Edward S.
Croes, J. J. R.
Drummond, M. J.
Fisher, E. A.
Fuller, Geo. W.
Gubelman, Fred. J.
Heermans, H. C.
Hill, Nicholas S., Jr.
Hodgkins, H. C.
Knudson, A. A.
Lockwood, Chas. A.
Lyon, Henry L.
Mason, W. P.
Newton, Howard D.
Shepperd, F. W.
Toal, D. C.
Volkhardt, William
Whipple, Geo. C.
Babcock, S. E.
Bassett, Geo. B.
Brightman, Horace I.
Bunting, N. W.
Cook, F. S.
Davy, T. W.
Dunham, H. F.
Fitzpatrick, Jas. R.
Gallagher, John F.
Hague, C. A.
Hering, Rudolph
Hill, Wm. R.
Kelley, John C.
Kuichling, E.
Longyear, O. C.
McCarthy, Dan'l. B.
Milligan, R. E.
Peene, Edward L.
Smith, J. Waldo
Torrence, Kenneth
Warde, John S.
Witmer, J. F.
Bacot, R. C.
Bennett, Thos. H.
Boardman, Arthur E.
Caird, James M.
Crandall, Wm. S.
Dennis, Chas. E.
Farley, John M.
Foster, Ernest H.
Goodell, J. M.
Hazen, Allen
Herschel, Clemens
Hoagland, Ira Gould
Kelley, Nicholas J.
Little, Beekman C.
Lord, Harry A.
McKim, Robert Albert
Neville, Thos. J.
Sawyer, J. T.
Soper Geo. A.
Tubbs, J. Nelson
Wegman, Edward

ASSOCIATE.

Babcock & Wilcox Boiler Co.
Central Foundry Co.
Eddy Valve Mfg. Co.
Gillespie, T. A.
Kennedy, Daniel
Neptune Meter Co.
Ross Valve Co.
Bingham & Taylor
Day, Chas. R.
Fairbanks Co., The
International Steam Pump Co.
Ludlow Valve Mfg. Co.
New York Continental Jewell Filtration Co.
Sweet & Doyle Valve Co.
Buffalo Meter Co.
Drummond, M. J. & Co.
Gamewell Fire Alarm Telegraph Co.
Kellogg, E. H. & Co.
National Meter Co.
Rensselaer Mfg. Co.
Thomson Meter Co.

NORTH CAROLINA.—Total Membership, 8.

ACTIVE.

Bain, Ernest B.
Ludlow, J. L.
Milton, Richard H.
Campbell, Chas. H.
McCormick, W. T.
Robertson, Wm. F.
Knox, H. E.
Michie, John C.

NORTH DAKOTA.—Total Membership, 1.

ACTIVE

Russell, W. S.

OHIO.—Total Membership, 40.

ACTIVE.

Beardsley, Joseph C.	Bemis, Edward W.	Boeh, W. H.
Bolger, F. E.	Brotherton, Chas. F.	Brown, C. Arthur
Brown, Calvin S.	Chapin, L. E.	Clark, D. H.
Cook, T. H.	Dow A. R.	Ferguson, W. H.
Gerrish, Wm. Blanchard	Hamilton, W. S.	Harvey, Lee
Heisler, Chas. L.	Hill, John W.	Hornung, George
Jones, Geo. L.	Kingsley, Marvin W.	McAlpine, A. H.
Monjeau, C.	Ohliger, L. B.	O'Shaughnessy, Jerry
Penney C. L.	Rowe, Chas. E.	Strauss, Nathan
Veach, W. A.	Wiles, C. W.	

ASSOCIATE

American Valve & Meter Company	Bourbon Brass & Copper Company	Columbus Board of Public Service
Columbus Meter Seal Mfg. Co.	Dayton Board of Public Service	Farnan Brass Works
Glauber Brass Mfg. Co.	Platt Iron Works	Safety Meter Lock Co.
Todd, The William Co.	Yiser, L. B.	

OREGON.—Total Membership, 2.

ACTIVE.

Gates, H. V.

ASSOCIATE.

Hoge & Swift

PENNSYLVANIA.—Total Membership, 64.

ACTIVE.

Affleck, John	Alexander, W. A.	Boardman, W. H.
Clark, J. V.	Conlin, F.	Deery, John Jerome
Durlin, Willis B.	Elbert, Edward	Evans, J. Rittenhouse
Felix, Geo. H.	Forbes, Murray	Frailey, E. F.
Fuller, Allen J.	Gailey, S. A.	Goodnow, W. T.
Hand, F. L.	Harbster, M.	Harlow, Geo. R.
Higbee, I. M.	Hunter, W. J.	Hutton, Geo. J.
Jackson, Robt. J.	Kennedy, Geo. G.	Kuhn, W. S.
Kuhn, Jacob	Landes, J. D.	McCabe, H. Dallas
McConnell, W. C.	McWilliams, C. Q.	Maignen, P. A.
Marple, Wm. M.	Mather, Edmund	Mellon, T. A.
Meyers, A. H.	Miller, Jos. Torrence	Neubling, Emil L.
Prenter. Martin	Pollard, W. D.	Pugh, Marshall R.
Purdy, J. H.	Shepherd, A. B.	Sheppard, Jas. H.

Sprenkel, John F.
Verner, T. H.
Watson, Walter L.
Woodburn, Wm. F.
Taylor, Sam'l. A.
Wanner, P. D.
Wirt, R. D.
Wright, Millard F.
Trautwine, John C.
Watkins, Thomas
Wood, Walter
Young, Ezra P.

ASSOCIATE.

Adams, Lydon E.
Dresser, S. R.
Pittsburg Filter Mfg. Company
Wood, R. D. & Co.
American Pipe Mfg. Company, The
Hays Mfg. Co.
Pittsburg Meter Co.
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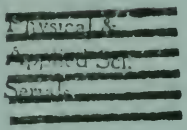

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